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Influence of Farmyard Manure, Gypsum and Sand on Chemical Properties of Heavy Clay Soil

A. M. El-Ghamry, E. M. El-Hadidi and Amira M. I. El-Emshaty
Department of Soil Science, Faculty of Agriculture, Mansoura University, Mansoura, Egypt.

THE EFFECTS of several soil amendments (sand, FYM and gypsum) on soil chemical properties were investigated in a field experiment conducted at Gammalia district, Dakahlia Governorate, Egypt. There were 10 treatments.: control, S_{10}, S_{20}, $G_{2.5}$, G_5, FYM_{10}, FYM_{20}, $S_{10}+G_{2.5}$, $S_{10}+FYM_{10}$ and $FYM_{10} + G_{2.5}$ ton/fed with 3 replicates. Two crops (cowpea, potato) were cultivated.

The results indicated that soil amendments decreased pH in all treatments under cowpea and potato and also decreased EC, but sand addition mixed with FYM has increased EC. FYM and gypsum, alone or incombination showed increase in OM% while sand, alone or coupled with gypsum decreased in OM. Soil amendments have good effect on the soluble cations and anions. Results revealed that the soil amendments addition to the studied soil decreased SAR value in all treatments compared with control. Also, all treatments decreased GR compared to the control.

Soils in the northern Nile Delta have been deposited under the conditions of Mediterranean Sea or saline lakes, thus they are characterized with heavy texture surface accumulation of soluble salts and low concentration of organic matter (Abbas *et al.*, 1967).

Armstrong & Tanton (1992) stated that gypsum application was highly efficient as a treatment for reducing the amount of exchangeable sodium and inhibiting clay dispersion in highly structured saline sodic clay top soils.

El-Fakharani (1997) mentioned that the effect of gypsum on soluble Ca^{++} in soil significantly increases the concentration of Ca^{++} in the soil solution. This is not strange since addition of gypsum promotes the availability of Ca^{++} in soil and that liberation of CO_2 as a results of biodegradation of poultry manure leading to the formation of carbonic acid (H_2CO_3) which encourages the dissolution of gypsum ($CaSO_4$-H_2O) in soil as a result of reducing the soil pH.

Studying the effect of gypsum and poultry manure on soluble HCO_3 and $CaCO_3$ concentration in soil, El-Fakharani (1997) reported that soluble HCO_3 concentration in the soil solution significantly decreased, while the $CaCO_3$ in the soil significantly increased as a result of increasing gypsum level to 8 t/ha. This

may be attributed to the probable reaction between Ca^{++} and HCO_3^- to form $Ca(HCO_3)_2$ which is precipitated as CaCO3 in the soil.

The aim of the present study was to evaluate the effect of different levels of soil amendments on soil chemical properties of heavy textured soil.

Material and Methods

The research entitled "Improving Heavy Textured Soil Properties" was conducted in the Soil Science Dept., Faculty of Agric., Mansoura University, Egypt. The study field is located in Gammalia district, Dakahlia Governorate, Egypt. A randomized completely block design (RCB) was used with 10 treatments and 3 replicates. The treatments were: control, sand 10, sand 20, FYM 10, FYM 20, gypsum 2.5, gypsum 5, sand 10+FYM10, sand 10+gypsum 2.5, and gypsum 2.5 + FYM 10 t/fed. The study included two crops (cowpea and Potato). The whole experimental area was 540 m^2.

The amendments were added before planting both of the crops (cowpea and potato) to the surface of soil and then ploughed to mix in the surface and sub surface layers.

After harvesting each crop, soil pH was measured in the 1:2.5 soil paste extract using Beckman glass electrode pH meter (Black, 1965). Soluble carbonate and biocarbonate were determined by the titration with standard HCl solution, while soluble calcium, magnesium and sulfate in 1.5 soil to water extract by the titration with a standardized versenate solution, also soluble standard silver nitrate solution (Jackson, 1967). Organic matter was determined according to Walkley and Black method (Black, 1965).

Some physical and chemical properties of the studied soil before planting are presented in Table 1.

TABLE 1. Some physical and chemical properties of the soil.

Soil physical properties	Soil sample		Soil chemical properties		Soil sample	
	0-20 cm	20-40 cm			0-20 cm	20-40 cm
H.W. %	10.53	10.05	pH value*		7.5	7.6
S.P. %	116.6	124.5	EC dS/m**		1.68	1.34
F.C %	47.5	45.0	O.M %		1.43	1.53
P.W.P %	25.2	24.8	GR t/fed		6.13	5.68
H.C. cm/h	0.041	0.065	Soluble cations meq / 100	Ca^{++}	1.16	1.18
BD g/cm³	1.25	1.28		Mg^{++}	1.12	1.04
RD g/cm³	2.67	2.72		Na^{+}	0.21	0.32
Total Porosity%	53.18	52.94		K^{+}	1.0	1.1
Coarse sand %	11.60	11.42	Soluble anions meq / 100	CO_3^{--}	0.0	0.0
Fine sand %	2.61	2.22		HCO_3^{-}	0.25	0.30
Silt %	20.4	20.84		Cl^{-}	1.94	1.88
Clay %	65.39	65.52		SO_4^{--}	1.10	1.40
Soil texture	Clayey soil		ESP		7.8	7.6

* In soil paste **In 1:5 extract (The soil used in this research was heavy clay soil)

Collected data were subjected to the statistical analysis, the technique of analysis variance (ANOVA) for Randomized Complete Block Design (R.C.B) according to Gomez & Gomez (1984) was used. The treatments means were compared using least significant difference (LSD).

Results and Discussion

Effect of some soil amendments on soil pH value and EC

Data in Table 2 showed the effect of sand, FYM, and gypsum and their combinations on soil chemical properties. Data revealed that the pH values were reduced with the application of amendments to the studied heavy textured soil as compared to control. This decrease was obvious for sand, FYM and gypsum at the two application rates and the combinations between them in all treatments under cowpea and potato crops.

TABLE 2. Effect of soil amendments on soil pH and EC under cowpea and potato crops.

Treatments	Cowpea		Potato	
	pH	EC, dS/m	pH	EC, dS/m
Control	7.6	1.37	7.6	1.37
S_{10}	7.4	1.21	7.5	1.34
S_{20}	7.5	1.17	7.5	1.34
FYM_{10}	7.2	1.58	7.1	1.66
FYM_{20}	7.2	1.67	7.2	1.68
$G_{2.5}$	7.0	0.45	6.9	0.40
G_5	7.1	0.58	7.0	0.62
$S_{10}+FYM_{10}$	7.4	1.40	7.4	1.47
$S_{10}+G_{2.5}$	7.3	0.98	7.4	1.22
$FYM_{10}+G_{2.5}$	7.3	1.42	7.3	1.42

S= Sand, FYM= Farmyard manure, G= Gypsum

The decrease in pH value by adding gypsum may be attributed to rapid leaching of soluble sodium salts and as a result for conditioning structure and porosity of soil, also to calcium replacing the exchangeable sodium. These results are in harmony with those obtained by Mohamed *et al.* (1992); Ramadan *et al.* (1994) and Bols'hkoov *et al.* (1996).

Furthermore, the results showed that FYM reduced slightly soil pH value. These finding are in agreement with those obtained by Singh & Singh (1989); Nazir *et al.* (1998) Adel - Moez *et al.* (1999) and Zein (1996). There are arguments that the decrease in soil pH could be attributed to the decomposition process of organic materials and reducing the organic acids.

Data in Table 2 revealed that EC value was reduced with application of used amendments to the studied soil as compared to the control under cowpea and

potato crop. This decrease in EC value may be due to the addition of gypsum, where the percolation of water through the profile of gypsum-treated soil was much more than without gypsum. These results are in agreement with those of Youssef (1992) who reported that the application of gypsum caused a significant decrease in soil EC value.

Effect of soil amendments on organic matter

Data in Fig. 1 revealed that the amendments application caused an increase in some treatments and a decrease in the others.

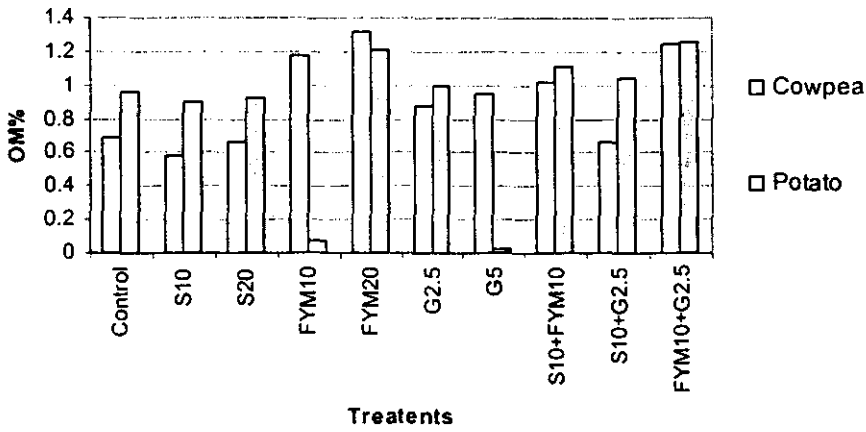

Fig.1. Effect of soil amendments on organic matter percentage under cowpea and potato crop .

Sand application at two rates under cowpea and potato crop decreased OM%, but the addition of sand mixed with FYM increased OM%. FYM addition alone or coupled with gypsum increased OM%.

It was observed that the effect of soil amendments on OM% under potato and cowpea crops has the same way in their effect. The organic matter was decreased by adding FYM. It could be concluded that the soil OM content decreased with time because the decomposition rate of applied manures was increased with increasing decomposition period and temperature (Amer *et al.*, 1996).

Effect of soil amendments on soluble anions

The effect of soil amendments (sand, gypsum and FYM) on soluble biocarbonates, chloride and sulphate anions in the soil solution under cowpea and potato crops are given in Table 3 .

The addition of sand under cowpea and potato crops at two rates,10 and 20 t/fed increased the soluble HCO_3^- and SO_4^{--}anions concentrations.

TABLE 3. Effect of using soil amendments on soluble anions (meq/100g soil).

Treatments	Cowpea				Potato			
	meq/100 g soil				meq/100 g soil			
	CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}	CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}
Control	0.00	1.02	1.99	1.40	0.00	1.25	1.59	1.43
S_{10}	0.00	1.08	1.71	1.60	0.00	1.48	1.68	1.46
S_{20}	0.00	1.52	1.65	1.50	0.00	1.57	1.87	1.45
FYM_{10}	0.00	1.88	1.88	1.70	0.00	1.65	1.37	2.30
FYM_{20}	0.00	1.90	1.53	1.70	0.00	1.55	1.45	2.40
$G_{2.5}$	0.00	0.66	0.88	2.80	0.00	0.86	0.31	2.60
G_5	0.00	0.57	0.73	2.80	0.00	0.68	0.32	2.80
$S_{10}+FYM_{10}$	0.00	1.68	1.78	1.88	0.00	1.90	0.98	2.40
$S_{10}+G_{2.5}$	0.00	0.63	1.28	2.20	0.00	0.78	0.83	2.70
$FYM_{10}+G_{2.5}$	0.00	1.07	1.18	2.60	0.00	1.28	0.96	2.80

S= Sand, FYM= Farmyard manure, G= Gypsum

The FYM application under cowpea and potato crops at two rates (10 and 20 t/fed) increases soluble HCO_3^- and SO_4^{--} concentrations. While both rates of sand decreased chloride concentration. Mixing sand with FYM affected studied anions by raising their concentrations except for chloride which decreased . On the other hand, mixing sand with gypsum decreased HCO_3^- and Cl^- but increased SO_4^{--} anions.

Data in Table 3 showed that soluble biocarbonate concentration in the soil solution was highly decreased by addition of gypsum. This may be attributed to the probable reaction between Ca^{++} and HCO_3^- to form $Ca(HCO_3)_2$ which precipitates as $CaCO_3$ in the soil.

On the other hand, FYM caused an increase in HCO_3 concentration, which can be attributed to the liberation of CO_2 as a result of the biodegradation of FYM and the consequent formation of carbonic acid (H_2CO_3) that promotes the dissolution of $CaCO_3$ resulting increase in the soluble HCO_3 anion in the soil solution.

Effect of soil amendments on soluble cations

Results in Table 4 showed the effect of soil amendments on soluble cations "Na^+, K^+, Mg^{++}, Ca^{++}" under cowpea and potato crop.

The addition of sand under cowpea and potato crops at two levels (10 and 20 t/fed) did not change the concentration of soluble cations.

FYM application under two growing crops at two rates (10 and 20 t/fed) decreased soluble cations (Na^+, K^+, Mg^{++}) and slightly Ca^{++}. Mixing sand, gypsum and FYM with each other showed the same trend for each amendment when applied alone.

TABLE 4. Effect of using soil amendments on soluble cations (meq/100g soil) under cowpea and potato crops.

Treatments	Cowpea				Potato			
	meq/100g soil				meq/100g soil			
	Na^+	K^+	Ca^{++}	Mg^{++}	Na^+	K^+	Ca^{++}	Mg^{++}
Control	1.40	0.73	1.26	1.02	1.05	0.77	1.43	1.02
S_{10}	1.41	0.67	1.28	1.03	1.033	1.07	1.47	1.05
S_{20}	1.44	0.70	1.48	1.05	1.033	1.32	1.50	1.04
FYM_{10}	1.235	1.44	1.75	1.03	1.040	1.52	1.58	1.18
FYM_{20}	1.036	1.32	1.72	1.05	1.031	1.45	1.72	1.20
$G_{2.5}$	1.025	0.63	1.64	1.04	1.021	0.09	1.60	1.06
G_5	1.022	0.68	1.36	1.04	1.010	0.12	1.64	1.03
$S_{10}+FYM_{10}$	1.393	1.42	1.50	1.03	1.025	1.50	1.60	1.15
$S_{10}+G_{2.5}$	1.028	0.72	1.32	1.04	1.024	0.65	1.54	1.10
$FYM_{10}+G_{2.5}$	1.430	1.05	1.34	1.03	1.025	1.29	1.56	1.16

S= Sand, FYM= Farmyard manure, G= Gypsum

The addition of gypsum enhanced the process of reclamation by the replacement of Na with Ca. The soluble sodium concentration was decreased as a result of adding gypsum because of the replacement of calcium with sodium in the soil solution. Also, Patel *et al.* (1990) concluded that gypsum was more effective in reducing the Na^+.

The results showed a high increase in the concentration of Ca^{++} by adding gypsum and FYM. This happened because addition of gypsum promoted the availability of Ca^{++} in soil and also for liberation of CO_2 by biodegradation of FYM resulting in carbonic acid (H_2CO_3) which encourages the dissolution of gypsum in soil as a result of reducing soil pH. These results are in agreement with those reported by Khafagi & Abdelhadi (1990) and El-Fakharani (1995 & 1996).

Effect of soil amendments on sodium adsorption ratio (SAR) under cowpea and potato crops

The sodium adsorption ratios (SAR) as affected by adding soil amendments (sand, FYM and gypsum) under cowpea and potato crops are given in Fig .2. Data revealed that the soil amendments addition to the studied soil decreased SAR in all treatments compared to control.

The addition of sand under cowpea and potato crops at two rates of 10 and 20 t/fed decreased slightly SAR from 1.3 and 0.92 to 1.28 and 1.20, respectively. Also, mixing sand at 10 t/fed with FYM at 10 t/fed or gypsum (2.5 t/fed) decreased SAR. This reduction was more obvious with gypsum than with FYM addition.

The addition of FYM under cowpea and potato crops at two rates (10 and 20 t/fed.) reduced SAR from 1.3 (control) to 1.0 and 0.86, respectively. This reduction was 23.08 and 30.77%, respectively.

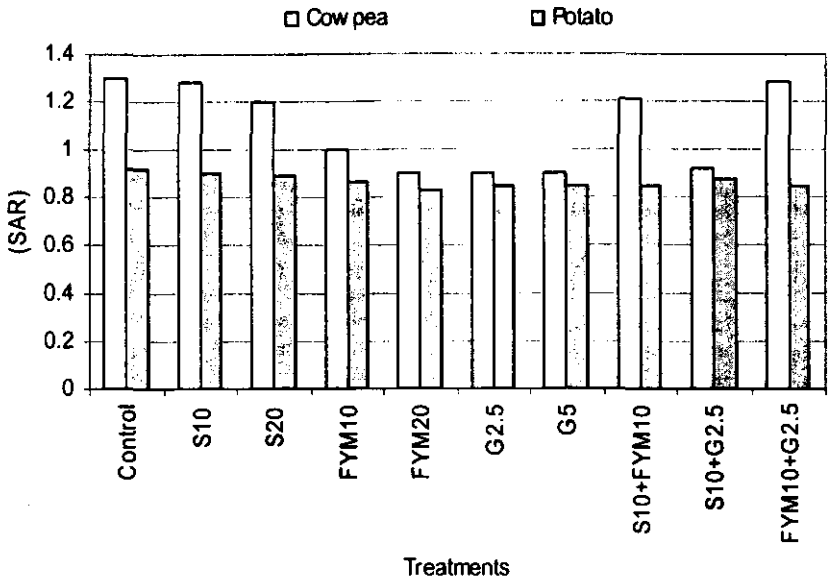

Fig. 2. Effect of using soil amendments on sodium adsorption ratio (SAR) under cowpea and potato crops.

On the other hand, gypsum application under cowpea and potato crops at two rates (2.5 and 5 t/fed.) sharply decreased SAR from 1.3 to 0.9 with 30.77% lowering for both rates.

Gypsum and FYM applications and their mixing with sand reduced SAR value. This could be explained on the base of adding soluble calcium through gypsum and leaching sodium from the soil solution.

Effect of using soil amendments on gypsum requirement (GR) under cowpea and potato crops

Data in Fig. 3 illustrated the response of gypsum requirement to the addition of different soil amendments (sand, FYM and gypsum) after two successive growing crops (cowpea and potato). All studied treatments decreased GR compared to the control.

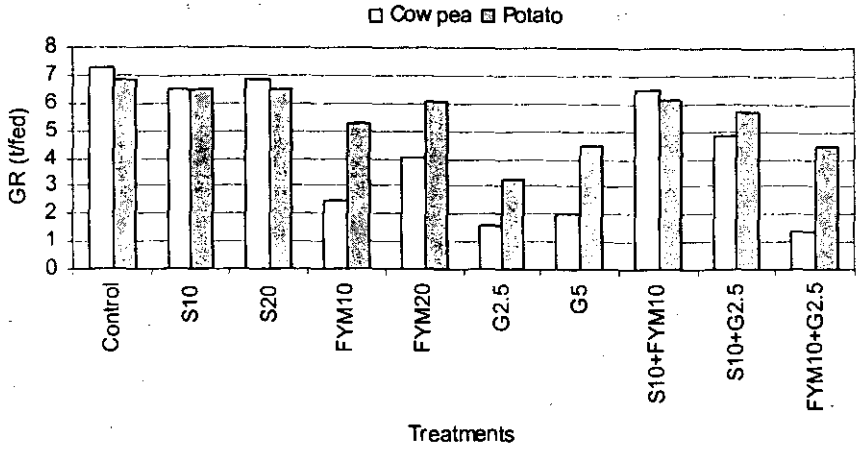

Fig. 3. Effect of using soil amendments on gypsum requirement (GR, t/fed) under cowpea and potato crops.

The sand application under cowpea and potato crops at two rates (10 and 20 t/fed.) decreased GR from 7.27 to 6.46 and 6.87 t/fed.

The FYM application under cowpea and potato crops at two rates (10 and 20 t/fed.) reduced GR sharply from 7.27 (control) to 4.42 and 4.04 t/fed. This reduction was 66.71 and 44.43%, respectively. While FYM at 10 t/fed mixed with gypsum at 2.5 t/fed reduced GR to 1.4 t/fed by lowering 8.74%. On the other hand, gypsum addition under cowpea and potato crops at two rates (G2.5 and G5 t/fed) reduced GR markedly from 7.27 to 1.62 and 2.02, respectively.

Mixing FYM or gypsum with sand or together takes the same trend. The decrease in gypsum requirements by using gypsum or FYM is due to the presence of Ca^{++} in their chemical composition or improving physical and chemical properties of studied heavy textured soil.

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تأثير المادة العضوية والجبس والرمل على الخواص الكيميائية لأرض طينية ثقيلة

أيمن محمد الغمري، السيد محمود الحديدي و أميرة محمود الأمشاطي
قسم الأراضي – كلية الزراعة – جامعة المنصورة – المنصورة – مصر.

أجريت تجربة حقلية خلال موسم ٢٠٠١ على تربة طينية ثقيلة في مركز الجمالية محافظة الدقهلية وتهدف لدراسة تأثير محسنات تربة مختلفة (رمل، سماد بلدي والجبس) على الخواص الكيميائية للتربة. أضيفت كل من محسنات التربة هذه بمعدلي إضافة في حالة فردية أو بالخلط مع بعضها البعض حيث أضيف الرمل بمعدلين هما (١٠، ٢٠ طن/فدان) والسماد البلدي بمعدلين هما (١٠، ٢٠ طن/فدان) وأضيف الجبس بمعدلين هما (٢,٥، ٥ طن/فدان) وكان تصميم التجربة المستخدم هو نظام القطاعات الكاملة العشوائية في ١٠ معاملات وهي كالآتي: الكنترول – الرمل بمعدل ١٠ طن/الفدان – الرمل بمعدل ٢٠ طن/الفدان – السماد البلدي بمعدل ١٠ طن/الفدان – السماد البلدي بمعدل ٢٠ طن/الفدان – الجبس بمعدل ٢,٥ طن/الفدان – الجبس بمعدل ٥ طن/الفدان – الرمل بمعدل ١٠ طن/الفدان + السماد البلدي بمعدل ١٠ طن/الفدان – الرمل بمعدل ١٠ طن/الفدان + الجبس بمعدل ٢,٥ طن/الفدن – السماد البلدي بمعدل ١٠ طن/الفدان + الجبس بمعدل ٢,٥ طن/الفدان وكانت النتائج كالآتي:

أدت إضافة المحسنات في وجود محصول البطاطس واللوبيا إلى خفض درجة تفاعل التربة (حموضة التربة) و إضافة الجبس عمل على خفض درجة تفاعل التربة وكذلك السماد البلدي وكان أعلى المعاملات في التأثير على خفض درجة تفاعل التربة هي إضافة الجبس بمعدل ٢,٥ طن/فدان. أدت إضافة الرمل بمعدليه إلى خفض الأملاح الكلية الذائبة بينما أدت إضافة السماد البلدي بمعدليه إلى زيادة التركيز الكلي للأملاح الذائبة وأدت إضافة الجبس بمعدليه إلى خفض الأملاح الكلية الذائبة. كما أدى الخلط بين الرمل والسماد البلدي إلى زيادة الأملاح الكلية الذائبة وكذلك إضافة السماد البلدي مع الجبس أدى إلى زيادة الأملاح الكلية الذائبة.

أدت إضافة الرمل إلى خفض النسبة المئوية للمادة العضوية بينما إضافة الجبس مع السماد البلدي أدت إلى زيادة النسبة المئوية للمادة العضوية. كما أدى الرمل مع الجبس إلى خفض النسبة المئوية للمادة العضوية كان أعلى زيادة للمادة العضوية عند إضافة السماد البلدي بمعدل ٢٠ طن / فدان في حالة محصول اللوبيا ولكن في حالة محصول البطاطس كانت أعلى زيادة في النسبة المئوية للمادة العضوية عند إضافة الرمل مع الجبس.

أدت إضافة السماد البلدي إلى زيادة البيكربونات الذائبة بينما أدت إضافة الجبس بمعدليه إلى خفض البيكربونات الذائبة. إضافة الرمل + الجبس أدى إلى خفضها بينما السماد البلدي المضاف مع الجبس أدى إلى زيادة البيكربونات الذائبة تحت محصولي البطاطس واللوبيا كما أدت أيضا إضافة الرمل مع السماد البلدي إلى زيادتها. تسببت محسنات التربة المختلفة (الرمل، السماد البلدي والجبس) في خفض نسبة الكلوريد الذائب في جميع المعاملات. وكان أعلى إنخفاض مع الجبس بمعدل ٥ طن/ فدان في حالة اللوبيا. بينما كان أعلى إنخفاض في حالة البطاطس مع إضافة الجبس بمعدل ٢,٥ طن/ فدان. الكبريتات الذائبة تأثرت بإضافة محسنات التربة المختلفة حيث أدت إضافتها إلى زيادة الكبريتات الذائبة في جميع المعاملات وكان أعلى إرتفاع في قيمتها مع إضافة الجبس بمعدليه ٢,٥، ٥ طن/فدان.

وأدت المعاملات إلى خفض تركيز الصوديوم الذائب وزيادة تركيز كل من الكالسيوم والمغنيسيوم والبوتاسيوم. وأدت إضافة جميع محسنات التربة المستخدمة إلى خفض النسبة الإدمصاصية للصوديوم في حالة محصول اللوبيا والبطاطس. الإحتياجات الجبسية إنخفضت بإضافة محسنات التربة (رمل، جبس وسماد بلدي) في جميع المعاملات.