J. King Saud Univ., Vol. **2**, *Agric. Sci.* (2), pp. 307-320 (1410/1990)

Effect of Three Commercial Conditioners on Available Water, Water Conserved, and Crust Strength of a Loamy Sand Soil

A.M. Al-Darby, M.A. Mustafa, A.M. Al-Omran, and M.O. Mahjoub

Soil Science Department, College of Agriculture, King Saud University, Riyadh, Saudi Arabia

Abstract. The effects of three commerical conditioners on available water, water conserved, and crust strength of a loamy sand soil (Typic Torripsamments) were investigated. The conditioners used included Agromousse (AGR), Perlite (PER), Peters (PET), and a mixture of equal amounts of PER and PET (PERT).

Treatments consisted of two irrigation intervals: 7 and 14- days, and four rates for each conditioner: 0, 0.5, 1, and 2 times the rate recommended by producers (RC). The RC rates were 0.6, 4, 8, and 6 % for AGR, PER, PET, and PERT, respectively. The application of RC, PER, PET, and PERT increased soil available water (AW) but did not significantly affect the amount of water conserved (WC) by the end of the 14- day cycle. Agromousse at this rate did not significantly affect soil AW but increased WC in both intervals. All conditioners applied at double RC substantially increased soil AW, but to a less extent reduced WC by the end of the fourth 7- day cycle. Furthermore, this rate did not significantly affect WC by the end of the 14- day cycle. The addition of all conditioners increased the modulus of rupture of the soil but not to the level that causes crusting problems.

Introduction

Most of the agricultural soils of Saudi Arabia are coarse-textured. These soils have low water holding capacity, excessive deep percolation losses, high evaporation rates, and in some cases surface crusting. Some of these constraints have been overcome by adding organic residues. Organic residue have been found to reduce evaporation rate and thus increase the amount of water conserved [1]. Relatively recent research have suggested that synthetic gel-forming conditioners may be the solution since they increase the ability of sandy soils to retain water [2-7]. Recently new forms of synthetic non gel-forming conditioners have been introduced to the market. The producers claim that their conditioners improve soil condition for better plant growth and productivity.

Thus the purpose of this study is to investigate the effect of three synthetic commerical conditioners on: (i) available water, (ii) intermittent water conserved in columns irrigated every 7 or 14 days, (iii) and crust strength of a loamy sand soil.

Materials and Methods

A bulk surface (0-0.25 m) sample from a loamy sand soil (Typic Torripsamments) was obtained from the college experimental and research farm located at Dierab. The sample was air-dried, crushed, and passed through a 2 mm sieve. Selected soil properties were determined by standard procedures [8]. Sand, silt, and clay were 81, 12, and 8 %, respectively. The percentage organic matter, pH, ECe (saturated extract), and $CaCO_3$ percent were 0.22, 8.0, 1.3 dSm^{-1}, and 36.4, respectively.

Three commercial conditioners, namely, Agromousse (AGR), Perlite (PER), Peters (PET) and a mixture of equal amounts of PER and PET (PERT) were used in this experiment. Agromousse is a white synthetic resin foam made from urea and formaldehyde. Perlite is silicon volcanic rock heated to produce material which has a white color, light weight, and granular shape. Peters is a potting soil, medium in weight and composed of Canadian sphagum peat moss, processed bark, and vermiculite. Soil subsamples (4 kg each) were separately and thoroughly hand-mixed (wet) with predetermined amounts of conditioners, air-dried, crushed, and passed through 2 mm sieve. Four application rates; 0, 0.5, 1, 2 times the rate recommended (RC) by producers (1:2, conditioner:soil by volume) were prepared for each conditioner. The RC rates calculated on weight basis were 0.6, 4, 8, and 6 % for AGR, PER, PET, and PERT, respectively.

Relative swelling index was defined as the amount of distilled water (g) retained at 1 -kPa suction per gram of soil minus the amount of 1 M $CaCl_2$ solution similary retained by a nontreated sample. The procedure used was similar to that described by Al-Omran *et al.* [6].

Water conservation studies were investigated, using 450 mm long columns (70 mm treated over 380 mm untreated soil) packed into glass tubes, 500 mm long with 55.3 mm i.d., and closed at one end by a piece of cloth firmly held by strings. Untreated soil was hand-packed to a depth mark of 380 mm and treated soil was packed on the top 70 mm of each column to simulate the application of conditioners into the plow layer. Resultant average bulk density was 1.56 Mg m^{-3}.

Treatments consisted of two irrigation intervals: 7 and 14 days and four conditioners each with four application rates. The quantity of water applied every 7, or 14 days were 25, or 50 mm, respectively. The application rates were 0, 0.3, 0.6, and 1.2 % for AGR; 0, 2, 4, and 8 % for PER; 0, 4, 8, and 16 % for PET; and 0, 3, 6, and 12 % for PERT. Each treatment was replicated thrice.

Soil columns were placed in circle on the bench of a walk-in growth chamber with controlled light of 25.7 Wm^{-2}, a constant temperature of 28°C, and a day/night cycle of 14/10 hr. Soil columns were hand-shifted daily around the table. Water loss was determined by periodic weighing. The percentage of water conserved (WC) was calculated as the amount of water conserved in the whole column divided by cumulative quantity of water applied and multiplied by 100. Soil columns were samples for gravimetric soil water content distribution by the end of the experiment. The study included four 7- day and one 14- day irrigation cycles.

Pressure-cooker and pressure plate apparati were used to determine the moisture contents at pressure 10 (FC, field capacity), and 1500 (PWP, permanent wilting point) kPa, respectively. Three determinations were made at each pressure. Moduli of rupture (MOR) of simulated crusts (briquets) were measured following the procedure suggested by Richards [9]. The details of the procedure are given in Richards [10]. The force required to break each briquet was measured in 6 briquets for each treatment. All variables measured were subjected to analysis of variance. Means comparisons were determined using the least significant differences (LSD) procedures [11].

Results and Discussion

Relative swelling

There was a significant increase in relative swelling index with increase in rate of all conditioners (Table 1). Relative swelling indices for 0.5RC, RC, and 2RC were about 2.3, 4.1, and 10.0 for AGR; 4.5, 7.8, and 16.7 for PET; 3.2, 6.4, and 9.3 for PER; and 2.7, 6.7, and 11.3 for PERT times those of the control, respectively. In general the relative swelling indices between conditioners ranked: PET > PERT > PER > AGR. The high swelling associated with PET and PERT is related to the vermiculite contained on them.

Infiltration

Time required for 25 (7-day cycle) or 50 (14-day cycle) mm of water to infiltirate (TRI) a loamy sand soil treated with four conditioners at four rates each, and for four successive 7- day and one 14- day irrigation cycles are shown in Table 2. For con-

Table 1. Relative swelling indices [1] as affected by four conditioners at four rates each

Rate %	conditioner			
	Agromousse	Perlite	Peters	Peters and Perlite
0.0 RC[2]	0.015	0.015	0.015	0.015
0.5 RC	0.035	0.048	0.067	0.040
1.0 RC	0.062	0.096	0.117	0.101
2.0 RC	0.150	0.139	0.250	0.169
LSD 0.05[3]	0.003	0.035	0.029	0.035

1 Relative swelling index is the amount of distilled water retained at 1 kPa by each sample minus 1 M $CaCl_2$ solution retained at 1 kPa by the non-treated sample.

[2] RC= the rates recommended by producers. They are 0.6, 4, 8, and 6 % for Agromouse, Perlite, Peters, and Peters and Perlite mixture, respectively.

[3] LSD0.05 = least significant differences at 0.05 level.

ditioners other than AGR, the TRI increased significantly (P=0.05) with increase in application rate for all cycles. For AGR the increase of TRI with increase in application rate was significant only in the first 7- day cycle and TRI was highest at RC (0.6 %) rate. For the first 7- day cycle the TRI for soil columns treated with 0.5 RC (0.3 %), RC (0.6 %), and 2RC (1.2 %) Agromousse were about 1.5, 2.0, and 1.6 times that of the control, respectively. The TRI of soil treated with 2RC rates of PER, PET, and PERT was significantly higher than that of the control. For 1st, 2nd, 3rd, and 4th 7- day cycle, the time required for 25 mm of water to infiltrate the soil columns treated with 2RC of PER were, respectively, 3.8, 2.0, 1.9, and 1.9 times that of the control. For PET, these TRI ratios for the same successive 7- day cycles in sequence were 3.3, 3.4, 3.5, and 3.5. Whereas for PERT these TRI ratios for the same cycles in sequence were 3.1, 2.9, 2.9, and 3.0. For the 14- day cycle, the time required for 50 mm of water to infiltrate into the soil columns treated with 2RC of PER, PET, and PERT were, respectively, about 1.8, 2.0, and 2.5 times those of the control. The addition of all conditioners caused soil swelling, and consequently reduced soil pore-sizes and increased infiltration time. In view of its fluffy structure, Agromousse applied at a rate of 2RC caused a more open pore system and hence reduced the infiltration time.

Available water

In general, field capacity and available water (AW=FC-PWP) of the soil treated with 0.5RC for all conditioners were equal to or significantly lower than those of the control (Table 3). Whereas FC and AW of the soil treated with RC and 2RC rates of all conditioners with the exception of AGR were significantly higher (P=0.05) than those of the control. The FC and AW of the soil treated with RC Agromousse were

Table 2. **Times required of water to infiltrate sandy loam soil treated with four conditioners at four rates each, and four successive 7- day irrigation cycles or 14- day cycle.**

Rate %	Time required for water[1] to infiltrate (min.)				
	7- day cycle				14- day cycle
	1st	2nd	3rd	4th	
			AGROMOUSSE		
0.0	2.55	3.67	3.93	4.24	18.78
0.3	3.88	4.03	4.91	4.67	14.27
0.6	4.98	4.14	5.07	5.65	24.88
1.2	4.20	4.04	4.58	4.42	17.06
LSD0.05[2]	1.09	ns[3]	ns	ns	ns
			PERLITE		
0	2.55	3.67	3.93	4.24	18.78
2	5.93	4.32	5.55	5.74	30.44
4	6.01	4.59	5.47	5.90	29.74
8	9.79	7.35	7.55	7.92	32.87
LSD0.05	3.52	2.37	2.14	1.61	4.29
			PETERS		
0	2.55	3.67	3.93	4.24	18.78
4	4.78	7.08	7.91	9.47	26.35
8	7.47	9.62	10.60	12.04	33.81
16	8.34	12.34	13.75	14.65	37.61
LSD0.05	1.30	2.17	3.51	3.01	2.17
			PERLITE and PETERS		
0	2.55	3.67	3.93	4.24	18.78
3	4.22	5.74	6.07	6.37	25.18
6	5.80	6.84	7.83	8.57	29.03
12	7.88	10.65	11.28	12.77	46.22
LSD0.05	1.75	2.41	2.54	2.88	11.57

[1] 25 mm for 7- day cycle and 50 mm for 14- day cycle.
[2] LSD0.05 least significant differences at 0.05 level.
[3] ns = not significant.

equal to those of the control. In general PWP of soil increased with addition of 0.5RC rate of all conditioners (Table 3). The PWP increased with further increase of all conditioners with the exception of PER. The PWP of PER decreased significantly with further increase in application rates.

The AW of the soil treated with 0.5RC (0.3 %), RC (0.6 %), nd 2RC (1.2 %) Agromousse were 0.86, 0.97, and 1.12 times that of the control. The lower FC and AW of 0.5RC (0.3 %) treated soil compared to the control and their gradual increase with higher rates may be explained in view of two opposed effects: the promotion of higher percentage of macropores by AGR and its ability to retain water. The counter

Table 3. Field capacity (FC), Permanent wilting point (PWP), and available water (AW) of loamy sand soil as affected by conditioner type and rates.

Rte	FC	PWP	AW
	%		
	AGROMOUSSE		
0.0	14.71	2.86	11.85
0.3	13.40	3.25	10.15
0.6	14.80	3.33	11.47
1.2	16.80	3.52	13.28
LSD0.05[1]	0.83	0.04	0.81
	PERLITE		
0	14.71	2.86	11.85
2	14.91	3.30	11.61
4	18.28	3.15	15.13
8	24.86	2.97	21.89
LSD0.05	1.28	0.06	1.32
	PETERS		
0	14.71	2.86	11.85
4	15.92	3.51	12.40
8	18.90	4.22	14.68
16	28.43	5.77	22.66
LSD0.05	1.38	0.13	1.38
	PERLITE AND PETERS		
0	14.71	2.86	11.85
3	14.77	3.78	10.99
6	17.97	4.07	13.90
12	22.83	4.96	17.87
LSD0.05	0.56	0.11	0.48

[1] LSD0.05 least significant differences at 0.05 level.

balance between the two effects resulted in more water drained from 0.5RC (0.3 %) treated soil and equal or more water retained in soils treated with higher rates compared to the control.

For Perlite, the addition of 0.5RC (2 %) had no significant effect on AW. Whereas the addition of RC (4 %) and 2RC (8 %) significantly increased FC, decreased PWP, and consequently increased AW. Avaliable water was increased by about 28, 85 % due to addition of RC (4 %) and 2RC (8 %) of PER, respectively. This response is mainly due to the ability of PER to retain water at high soil water potential (-10 kPa), and its failure to retain it at low water potential (-1500 kPa).

Field capacity, PWP, and AW increased with increase in rate of Peters application. The increase in AW was not significant at 0.5RC (4 %). Whereas at RC (8 %), and 2RC (16 %) the increase in AW was about 24, and 91 %. The effect of PERT was a combination of the effects of PER and PET. The addition of 0.5RC (3 %) PERT reduced the AW by about 7 %. Whereas the addition of RC (6 %), and 2RC (12 %) increased the AW by about 17, and 51 %, respectively.

In comparison among conditioners, the increase in AW compared to the control for the soil treated with 2RC ranked PET > PER > PERT > AGR (Table 3).

Water conserved

In most cases for 7- day irrigation cycle, the addition of all conditioners at 0.5RC did not significantly affect the percentage of water conserved (WC) by the soil (Table 4). In the third and fourth 7- day cycle, the addition of RC (0.6 %) of AGR significantly increased WC. By the end of fourth 7- day cycle, the addition of 2RC reduced the WC by about 7, 12, 26, and 21 for AGR, PER, PET, and Pert, respectively. The addition of 0.6 % AGR increased WC by 20 %. For the 14- day irrigation cycle, the addition of PER, PET, and PERT did not significantly affect the WC. In the case of AGR, the addition of 2RC significantly increased the WC. The negative effect on WC is mainly due to the ability of conditioners to retain water at the treated top soil columns (Figs. 1 and 2) and make it accessible for higher evaporation.

Splitting the same quantity of irrigation water into two doses reduced the amount of water conserved. This effect was much pronounced in high rates. The WC by the end of 14- day cycle in soil columns treated with 2RC were higher than those by the end of second 7- day cycle by about 39, 45, 25, and 30 % for AGR, PER, PET, and PERT, respectively. General comparison among conditioners used in term of WC showed that conditioners ranked PER > AGR > PERT > PET.

Figs 1 and 2 show the soil water profiles at the termination of the fourth 7- day cycles and the 14- day cycle, respectively. All profiles show a drying zone at the sur-

Table 4. The percentage of water conserved as affected by four conditioners at four rates each, and four successive 7- day irrigation cycles or 14- day cycle.

Rate %	7- day cycle				14- day cycle
	1st	2nd	3rd	4th	
			AGROMOUSSE		
0.0	32.4	31.6	29.3	26.9	33.0
0.3	31.8	31.6	30.9	30.6	34.7
0.6	33.0	33.4	32.7	32.1	34.7
1.2	27.0	26.7	25.4	24.9	37.3
LSD0.05[1]	4.3	4.2	3.6	3.6	2.6
			PERLITE		
0	32.4	31.6	29.3	26.9	33.0
2	30.3	30.1	29.8	28.4	36.6
4	29.6	28.0	26.7	27.0	35.2
8	28.4	26.6	24.6	23.8	38.5
LSD0.05	2.7	3.3	3.3	ns[2]	ns
			PETERS		
0	32.4	31.6	29.3	26.9	33.0
4	30.5	26.8	24.7	23.1	33.9
8	27.6	25.2	22.6	20.9	33.4
16	26.7	24.9	22.0	19.8	31.1
LSD0.05	2.6	3.1	2.8	2.8	ns
			PERLITE AND PETERS		
0	32.4	31.6	29.3	26.1	33.0
3	29.1	27.9	26.3	25.2	33.1
6	27.9	26.3	24.4	22.8	32.1
12	28.0	26.1	23.3	20.7	34.0
LSD0.05	3.2	3.7	3.2	3.1	ns

[1] LSD0.05 least significant differences at 0.05 level.
[2] ns = not significant.

face, transmission zone in the middle, and a wetting zone at the bottom. The PER, PET, and PERT profiles by the end of the fourth 7- day cycle (Fig. 1), and PET, and PERT profiles by the end of the 14- day cycle (Fig. 2) showed water storage zones at a depth of 35- 70 mm. In general at that zone for the three conditiners, the soil water content increased with increase of application rate. This effect was more marked in the 7- day cycle than 14- day cycle.

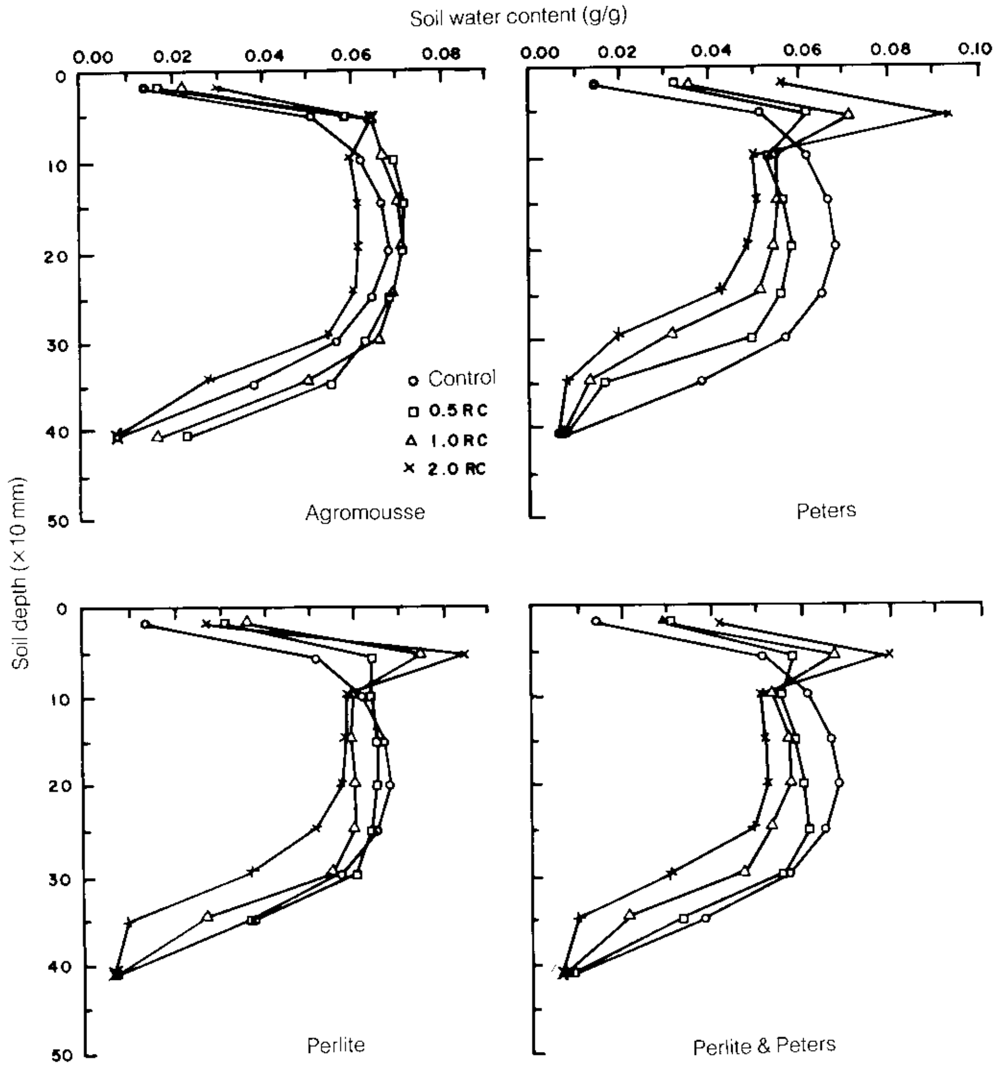

Fig. 1. Soil water profiles at the end of the fourth 7- day irrigation cycles as affected by four conditioners at four rates each. The rates recommended (RC) by producers were 0.6, 4, 8, and 6 % for Agromousse, Perlite, Peters, and Peters and Perlite mixture, respectively.

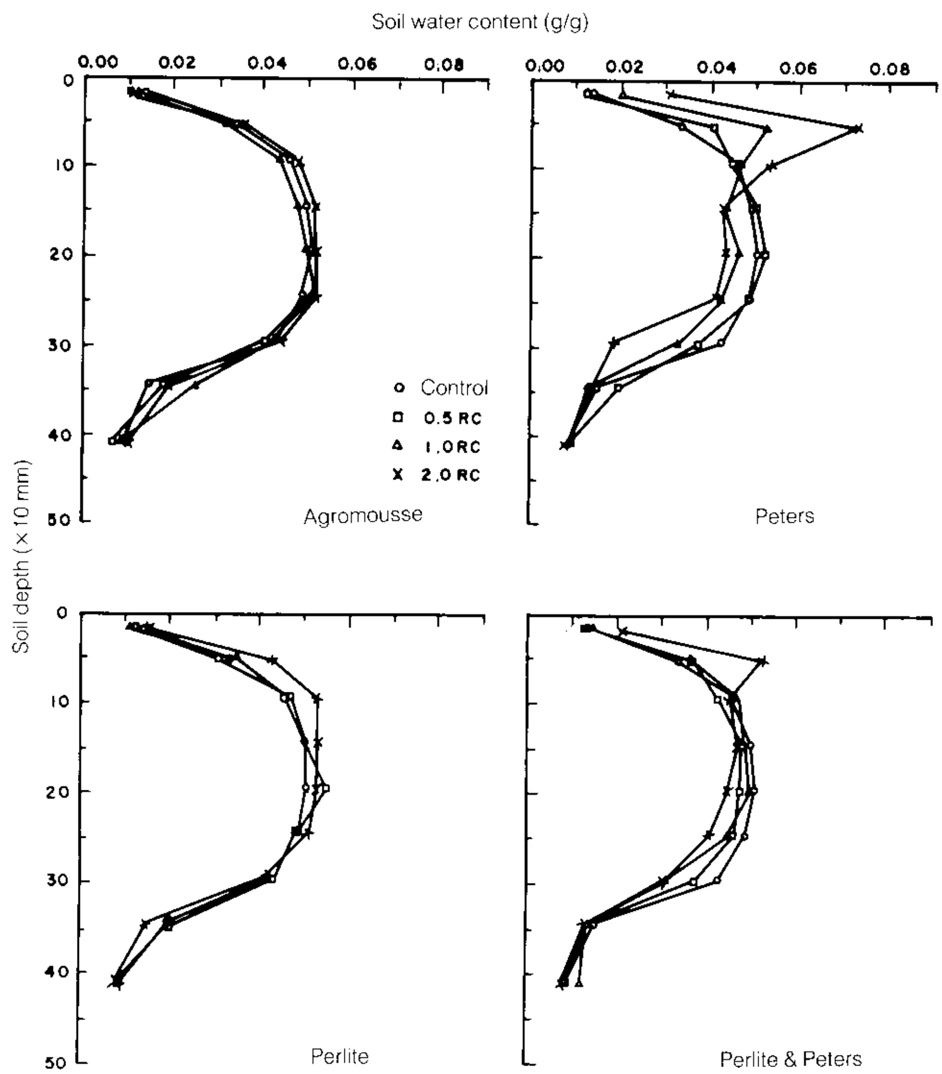

Fig. 2. Soil water profiles at the end of the 14- day irrigation cycle as affected by four conditioners at four rates each. The rates recommended (RC) by producers were 0.6, 4, 8, and 6 % for Agromousse, Perlite, Peters, and Peters and Perlite mixture, respectively.

Moudulus of rupture

The MOR vs. application rate relationships exhibited maxima at 0.5RC for PER and PET, and at RC for AGR and PERT. Half the recommended rate of all conditioners was sufficient to cause significant increase in MOR of the soil. Increasing AGR and PERT rates to 1RC resulted in significant increase of MOR and then decreased with further increase to 2RC. A further increase of PER and PET decreased the MOR. The reductions were slight as rates increased to 1RC and significant as rates increased to 2RC.

Bulk density of briquets at the time of measurement decreased with rate increase of all conditioners. The maximum bulk density differences between treatments were 0.25, 0.15, 0.25, and 0.12 Mg m^{-3} for AGR, PER, PET, and PERT, respectively. The bulk density coefficient of variations between treatments for particular conditioner, and for all conditioners were less than 6 %. Water content of briquets at the time of measurement increased with rate increase of all conditioners. The maximum water content differences between treatments for particular conditioner, and for all conditioners were less than 0.005 g g^{-1}. These data indicated no drastic changes in bulk density and water content of briquets with conditioners rate increase to affect the MOR in this experiment. Thus the response of MOR among treatments of particular conditioner or among conditioners is mainly related to the direct conditioners effect.

Increasing conditioner rate to 0.5RC of PER and PET and RC of AGR and PERT caused complete cross-linking between the loamy sand microaggrigates and thus cementing them by the drying process that followed the water saturation process resulted on maximum MOR. It seems that with further increase of rates beyond those which caused maxima, some cross-linking occurred between conditioner particles themselves. This weakened the strength of bonds between soil particles and resulted in reduced MOR. At rates that caused maxima, the MOR increased by about 2.0, 2.8, 2.1, and 2.6 times those of the control for AGR, PER, PET, and PERT, respectively. Alymore and Sill [12] selected a MOR value of 60 kPa as the lower limit for soils with crusting problems. The maximum MOR values measured were 41.0, 58.3, 43.3, and 54.1 kPa for AGR, PER, PET, and PERT, respectively. Thus although the addition of these conditioners may increase MOR of loamy sand soil, no crusting problems are expected to occur.

Conclusions

The addition of all conditioners increased modulus of rupture of the loamy sand soil to a level that are not expected to cause crusting problems.

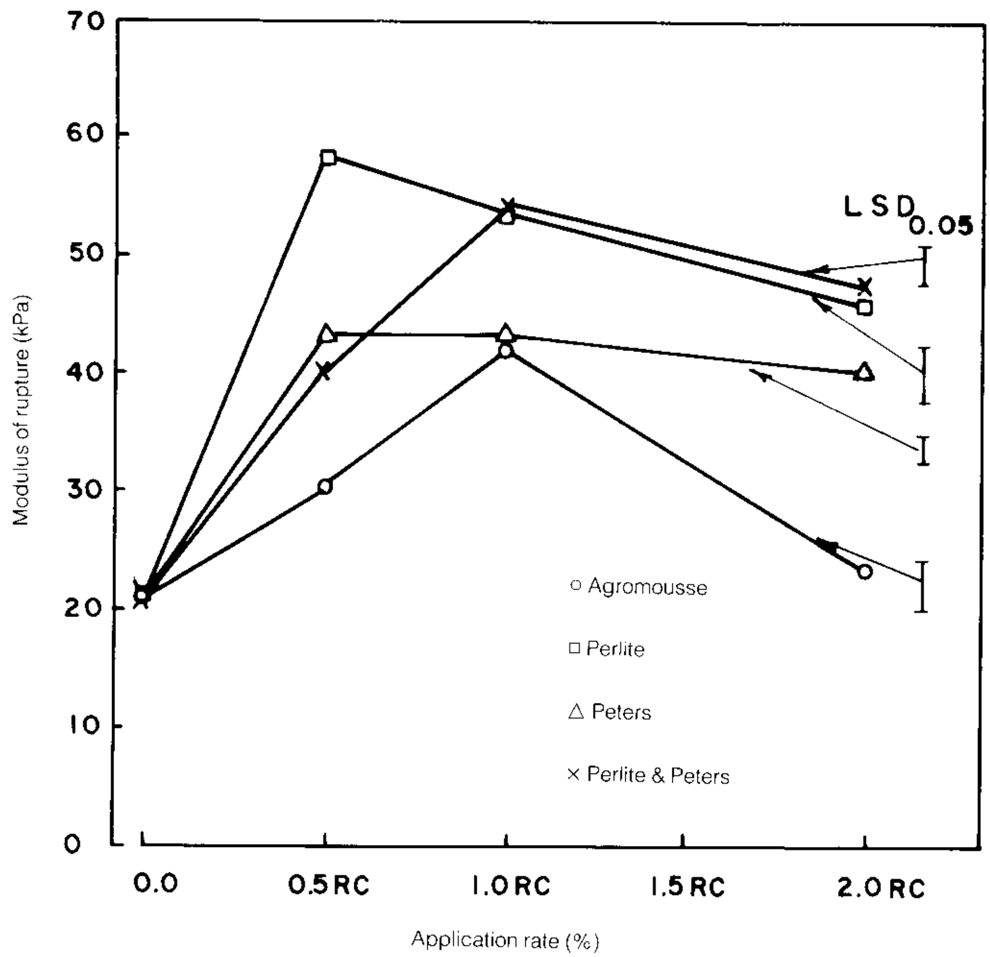

Fig. 3. Moduli of rupture as affected by four conditioners at four rates each. The rates recommended (RC) by producers were 0.6, 4, 8, and 6 % for Agromousse, Perlite, Peters, and Peters and Perlite mixture, respectively.

The addition of Peters and Perlite and Peters mixture at the rate recommended by producers (RC) increased the soil available water (AW) but reduced the amount of water conserved (WC) by the end of the fourth 7- day cycle to the same extent. However, this rate did not significantly affect the amount of water conserved by the end of the 14- day cycle. Thus application of RC Peters and Perlite and Peters mixture may prove effective in improving the soil moisture condition in the 14- day cycle but not the 7- day cycle. Since RC Perlite increased soil AW but did not significantly affect WC for both intervals, it may prove to be effective. Although RC Agromousse did not increase soil AW it might prove effective at this rate since it increased WC at both intervals.

Doubling RC for all conditioners resulted in increases in AW higher than reductions in WC by the end of the fourth 7- day cycle. This suggest that at this rate all conditioners may prove effective at the 7- day interval. However, their effectiveness may be improved by the use of heavier irrigation with longer interval.

References

[1] Al-Darby, A.M., Mustafa M.A., Al-Omran A.M. and Mahjoub M.O. "Effect of Wheat Residue and Evaporative Demands on Intermittent Evaporation." *Soil Tillage Res.*, (Submitted) (1989).

[2] Miller, D.E. "Effect of H-SPAN on Water Retained by Soils after Irrigation." *Soil Sci. Soc. Am. J.*, **43** (1979), 628-629.

[3] Page, E.R. "The Effect of Polyvinylalcohol on the Crust Strength of Silty soils." *J. Soil Sci.*, **30** (1979), 643-651.

[4] Hemyari, P. and Nofziger D.L. "Super Sluper Effects on Crust Strength, Water Retention and Water Infiltration of Soils." *Soil Sci. Soc. Am. J.*, **45** (1981), 799-801.

[5] Johnson, M.S. "Effect of Soluble Salts on Water Absorption by Gel-Forming Soil Conditioners." *J. Sci. Food Agric.*, **35** (1984), 1063-1066.

[6] Al-Omran, A.M., Mustafa M.A. and Shalaby A.A. "Intermittent Evaporation from Soil Columns as Affected by a Gel-Forming Conditioner." *Soil Sci. Soc. Am. J.*, **51** (1987), 1593-1599.

[7] Al-Omran, A.M., Mustafa M.A. and Mursi M. "The Influence of Gel-Forming Conditioner on Water Retention and Crust Strength of some Calcarieous Soils." *J. Coll. Agric., King Saud Univ.*, **10** (1988), 199-207.

[8] Black, C.A. *methods of Soil Analysis*. Part I and 2. WI: American Society of Agronomy Madison, 1965.

[9] Richard, L.A. "Modulus of Rupture as an Index of Crusting of Soil." *Soil Sci. Soc. Am Proc.*, **17** (1953), 321-323.

[10] Richards, L.A. *Diagnosis and Improvement of Saline and Alkali Soils*. U.S. Dept. Agric. Handbook No. 60. 1954.

[11] Steel, R.G.D., and Torrie J.H. *Principles and Procedures of Statistics*. New York: McGraw-Hill Book Co., Inc., 1980.

[12] Aylmore, L.A.G. and Sills I.D. "Characterization Soil Structure and Stability Using Modulus of Rupture- Exchangeable Sodium Percentage Relationship." *Aust. J. Soil Res.*, **20** (1982), 213-224.

تأثير ثلاثة محسنات تجارية على الماء الميسر، الماء المخزون، ومتانة القشور في تربة رمل طمي

علي محمد الدربي، مختار أحمد مصطفى، عبد رب الرسول العمران و محمد عثمان محجوب
قسم علوم التربة، كلية الزراعة، جامعة الملك سعود، الرياض،
المملكة العربية السعودية

ملخص البحث. أجريت دراسة حول تأثير ثلاثة محسنات تجارية على الماء الميسر، الماء المخزون، ومتانة القشور لتربة رمل طمي، شملت المحسنات: الأغروموس، البيرلايت، البيترز، وخليط متساوي الكمية من البيرلايت والبيترز.

احتوت المعاملات على فترتين من الري (٧ و١٤ يوم مع إضافة ٢٥ أو ٥٠ ملم كل رية على التوالي) وأربعة معدلات من كل محسن: صفر، ٠,٥، ١، ٢ مضروب في المعدل الموصى به بواسطة المنتجين والذي يساوي ٠,٦، ٤، ٨ و٦٪ لكل من الأغروموس، البيرلايت، البيترز، والخليط على التوالي.

أدت إضافة المعدل الموصى به من البيرلايت أو البيترز، والمخلوط المتساوي منهما إلى زيادة كمية الماء الميسر ولكنه لم يؤثر معنويًّا على كمية الماء المخزون في نهاية دورة الري الطويلة. أما إضافة الأغروموس فإن هذا المعدل لم يؤثر معنويًّا على كمية الماء الميسر ولكنها زادت من الماء المخزون عند نهاية دورتي الري الطويلة والقصيرة. مضاعفة هذا المعدل لكل المحسنات زاد من كمية الماء الميسر ولكنها خفضت بدرجة أقل من الماء المخزون عند نهاية دورة الري الرابعة القصيرة. ولكن هذا المعدل لم يؤثر على المخزون في نهاية دورة الري الطويلة. إضافة جميع المحسنات أدت إلى زيادة في معامل الكسر ولكن هذه الزيادة لم تصل إلى الحد الحرج الذي يتوقع عنده حدوث مشكلة تقشر التربة.