4. RESULTS AND DISCUSSION

Results and discussion of data of the current study will be presented separately for each of the five experiments. Two main aspects (for each experiment) will be dealt with. Firstly data regarding plants, secondly data regarding the soil after harvest.

Plant data include yields, and yield fractions as in experiments 1 to 3. In these three experiments, wheat was grown. Parameters such as yields of straw and grains as well as their total will be discussed. The total yield reflects the overall response of plant to the applied treatments. The straw yield and the grain yield, each reflects the specific response of such portions of wheat yields to the applied treatments. Other parameters such as plant height, and spike length would be presented tables in the appendix.

Soil data involves soil analysis at termination of the experiments after harvest of wheat or cutting of alfalfa. Discussion of soil analysis data will be done on the basis of the mean values for the entire depth of soil pots (i.e., the mean for the three successive soil depths of 0-5, 5-10 and 10-15 cm). Although soil properties of EC, and soluble ions (Na^+, K^+, Ca^{++}, Mg^{++}, Cl^-, $SO_4^=$, $CO_3^=$ and HCO_3^-) were determined, discussion involves EC, Na^+ and Cl^- since such parameters are of vital importance in salinity hazards on plants.

Data in details, considering the numerous soil and plant parameters as well as soil depths, are presented in tables in the current study. Part of these tables is within the text. The others are presented in two appendices. Appendix 1 includes data on some plant parameters (wheat height and spike length) as well as soil salinity data for the mean of the entire soil depth in pots (0-15 cm), which represent means of result analysis of the 3 soil layers (0-5, 5-10 and 10-15 cm) as well as a diagram of USDA salinity-sodicity modified classification of irrigation water. Appendix 2 on the other hand, includes soil salinity data of each of the 3 layers of the soil (0-5, 5-10 and 10-15 cm).

Experiment 1: irrigation intervals:

In this experiment, 3 intervals of the period between irrigations were used i.e., 3-day (I_1), 6-day (I_2) and 9-day (I_3) intervals.

Total yield (grain + straw) "Table 4 and Fig. 1"

Yield increased by increasing the interval period between irrigations. Average values (Table 4) show that the increase was greatest with the medium period interval (I_2) and the lowest with the short period (I_1) followed by the long period (I_3) intervals. Increases were 34.5 % and 21.4 % using I_2 and I_3, respectively, in comparison with the yield obtained by the 3-day interval (I_1).

The 6-day and the 9-day intervals gave greater yields compared with the 3-day interval. The medium irrigation frequency, i.e., the 6-day frequency was the most appropriate to get the highest yield. The lowest irrigation frequency gave the lowest yield. Increasing the period to 9 days between irrigations may have tended to cause stress in the root zone and decreasing it to 3 days may have caused depletion of nutrients by leaching. **Mashhady and Heakal (1983)** found that wheat was most affected by salinity after 4 weeks of irrigation with saline water. Yields of the 3-day and 9-day intervals were smaller by 25.7 %

Table (4): Effect of irrigation intervals with using light and heavy soils on total yield (grains + straw) g/pot of wheat irrigated with saline water (3.59 dS/m).

Soil [S]	Irrigation intervals (day) [I]			
	3-day (I_1)	6-day (I_2)	9-day (I_3)	Mean
Clay (S_1)	20.71	32.78	29.37	27.62
Sandy clay (S_2)	21.19	23.58	21.55	22.11
Sand (S_3)	4.30	5.79	5.22	5.10
Mean	15.40	20.72	18.71	
LSD (0.05):	I = 0.03	S = 0.03	I ×S = 0.06	
LSD (0.01):	I = 0.04	S = 0.04	I × S = 0.08	

Table (5): Effect of irrigation intervals with using light and heavy soils on grain yield (g/pot) of wheat irrigated with saline water (3.59 dS/m).

Soil [S]	Irrigation intervals (day) [I]			
	3-day (I_1)	6-day (I_2)	9-day (I_3)	Mean
Clay (S_1)	6.34	18.10	13.30	12.58
Sandy clay (S_2)	8.30	10.78	12.70	10.59
Sand (S_3)	1.70	2.49	2.04	2.08
Mean	5.45	10.46	9.35	
LSD (0.05):	I = 0.32	S = 0.32	I ×S = 0.57	
LSD (0.01):	I = 0.43	S = 0.43	I × S = 0.75	

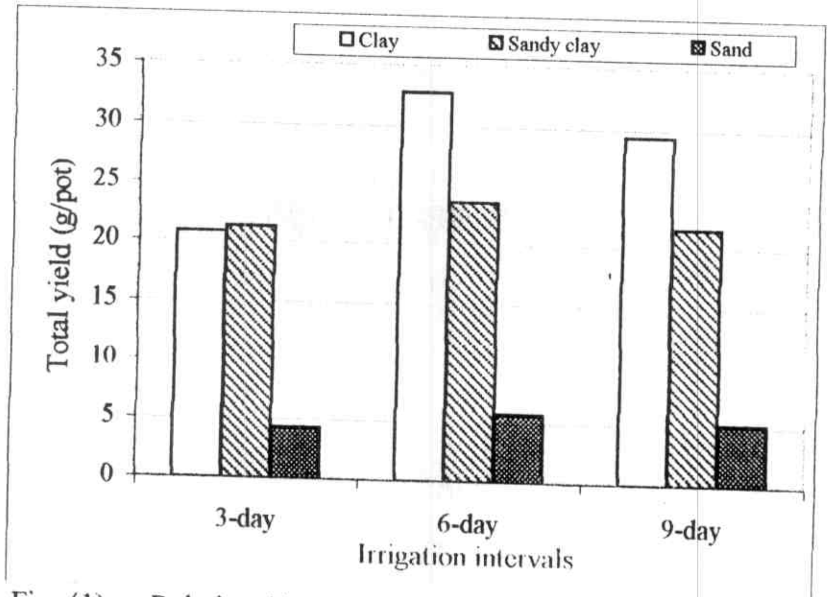

Fig. (1): Relationship between total yield and irigation intervals.

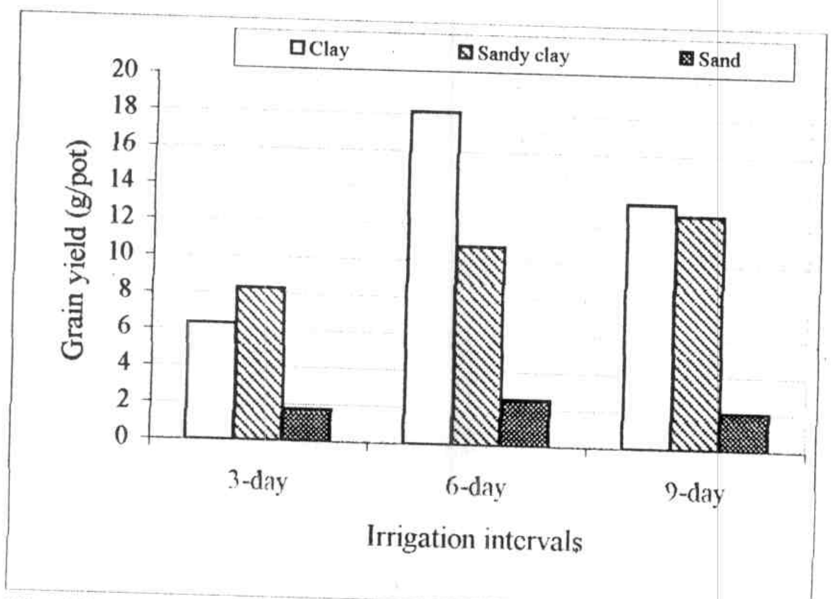

Fig. (2): Relationship between grain yield and irigation intervals.

and 9.7 % (on average), respectively, in comparison with the yield obtained by the 6-day interval. The magnitude of low yield due to the shortest interval (I_1) was greater in the clay and sand soils (being 36.8 and 25.7 %, respectively) than in the sandy clay soil (10.1 %). Therefore, the negative effect of the wetest treatment (the 3-day interval) in comparison with the medium (the 6-day) treatment was marked in the heavy and the light soils than in the medium-textured soil. High frequency watering must have depleted the soils (particularly the sand one) of nutrients. Besides, a condition of anaerobiosis may have taken place in the clay soil, where the 3-day interval was carried out leading to oxygen stress for plant roots as well as losses of N by dentrification.

Grain yield "Table 5 and Fig. 2":

Yield increased by increasing the interval period between irrigations. The lowest grain yield occurred with I_1 and the highest was with I_2. Increases were 91.9 % and 71.6 % using I_2 and I_3, respectively, related to the use of I_1. Such a pattern of response was most pronounced in the clay soil. In this soil increases were 185.5 % and 109.3 % due to I_2 and I_3 over I_1. In the medium-textured soil (the sandy clay soil), increases were less, being 29.9 % and 53.0 %, respectively, but were progressive. With the sand soil increases were 46.5 % and 20.0 %, respectively. In particular soil both I_2 and I_3 were not significantly different from each other.

Thus, the 6-day interval gave the highest grain yield in comparison with either the 3-day or the 9-day intervals only in the clay soil; and to some extent in the sand one. In the sandy clay soil, the 9-day interval gave the greatest grain yield. Decreasing irrigation frequency would lead to increase soil moisture in the root zone, possibly creating anaerobic conditions for roots in the clay soil and causing leaching losses particularly in the sand soil and the sandy clay one. In the medium textured soil, the 9-day interval gave the highest grain yield indicating that a long interval between irrigations is more suited to this soil. Moisture stress in the clay soil using 9-day interval seemed of greater effect as compared with the sandy clay one.

Straw yield "Table 6 and Fig. 3":

The differences, which were obtained, either between the yield of I_2 and the yield of I_3 or between the yield of I_3 and the yield of I_1 were not statistically significant.

This shows that the straw yield of the wheat plant was not affected by increasing or decreasing irrigation intervals and its subsequent effect on the root zone of the plant. The interval period between irrigations is not recommended to be very long, since it may subject plants to salinity stress (and also to water stress). Decreasing the irrigation interval gave a positive response, particularly in the heavy soil. Such a decrease, however should not be excessive (as with I_1), since it may lead to possible negative effect on plant growth. Such an effect was particularly evident in the heavy textured soil. Negative effects on plant growth may have occurred due to possible loss of nutrients by leaching, as well as to decreased aeration of the root medium may have taken place.

N-uptake by total yield "Table 7 and Fig. 4":

N-uptake by the total yield increased by increasing the interval period between irrigations. The increase was greatest using the 6-day interval (I_2). Increases were 34.6 % and 9.0 % using 6-day (I_2) and 9-day (I_3) intervals, respectively, related to the use of 3-day interval (I_1). Both I_2 and I_3 gave significantly higher N-uptake than I_1.

There was interaction caused by the texture of the soil, since in the most coarse soil (S_3), the sandy soil, the differences between irrigation intervals were not significant. In the clay soil (S_1), on the other hand the I_3 treatment gave greater N-uptake than the I_1 treatment.

Increasing irrigation frequency to its highest value, i.e., irrigation every 3 days was associated with the least N-uptake by plant. Moderate irrigation interval frequency, i.e., irrigation every 6 days gave the highest N-uptake by the total yield. Decreasing irrigation frequency i.e., irrigation every 9 days gave lower N-uptake by total yield than the 6-day irrigation interval. Thus, moderate irrigation interval gave the highest N-uptake. Increasing the period between irrigation would lead to an increased salinity stress since soil moisture would reach a lower level in the root medium towards the end of the period. This would lead to a decrease in yield as well as N uptake **(Pessarakli and Tuckers, 1988)**. On the other hand, a decrease in the period to an excessive level would increase the rate of nutrient leaching and leads to a reduction in aeration, consequently, decreasing N-uptake by plant.

Table (6): Effect of irrigation intervals with using light and heavy soils on straw yield (g/pot) of wheat irrigated with saline water (3.59 dS/m).

Soil [S]	Irrigation intervals (day) [I]			
	3-day (I_1)	6-day (I_2)	9-day (I_3)	Mean
Clay (S_1)	14.37	14.68	16.08	15.04
Sandy clay (S_2)	12.88	12.80	8.85	11.51
Sand (S_3)	2.60	3.30	3.18	3.03
Mean	9.95	10.26	9.37	
LSD (0.05):	I = 1.62	S = 0.1.62	I ×S = NS	
LSD (0.01):	I = 2.22	S = 2.22	I × S = NS	

NS = not significant

Table (7): Effect of irrigation intervals with using light and heavy soils on N-uptake by total yield (grains + straw) mg N/pot of wheat irrigated with saline water (3.59 dS/m).

Soil [S]	Irrigation intervals (day) [I]			
	3-day (I_1)	6-day (I_2)	9-day (I_3)	Mean
Clay (S_1)	320	513	499	444
Sandy clay (S_2)	495	588	391	491
Sand (S_3)	51	65	56	57
Mean	289	389	315	
LSD (0.05):	I = 9.15	S = 9.15	I ×S = 15.84	
LSD (0.01):	I = 12.59	S = 12.59	I × S = 21.81	

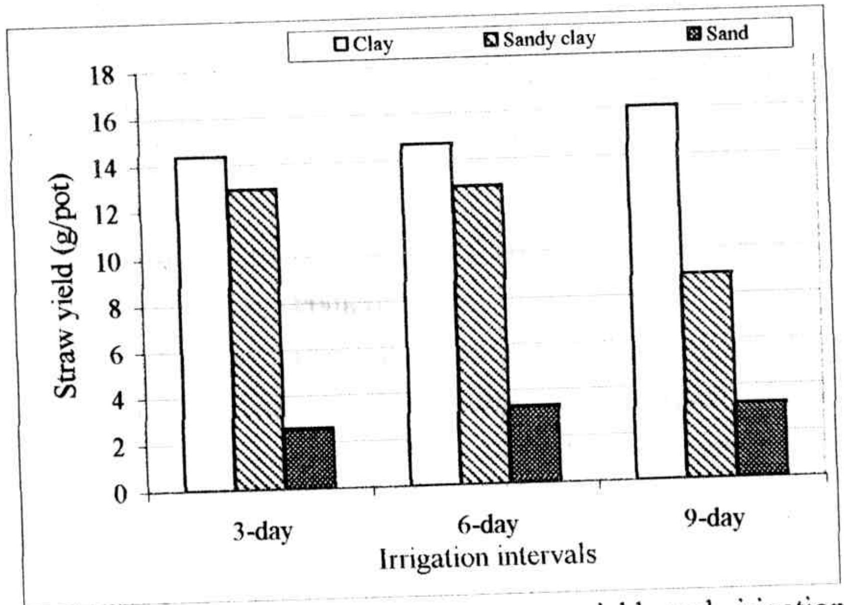

Fig. (3): Relationship between straw yield and irigation intervals.

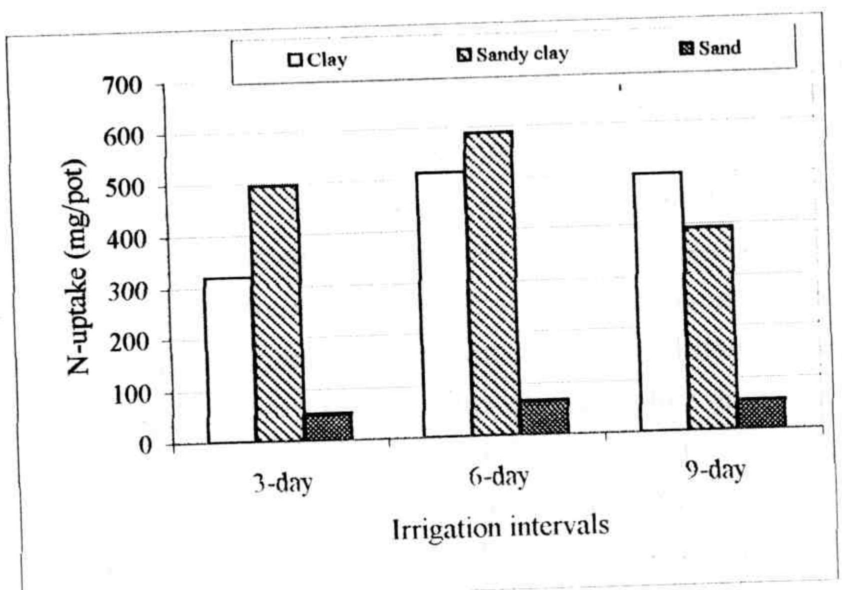

Fig. (4): Relationship between N-uptake and irigation intervals.

P-uptake by total yield "Table 8 and Fig. 5":

In the clay soil, P-uptake by plants of the I_2 treatment was highest followed by I_3 then I_1. In the sandy clay soil, highest uptake was given by the I_1 plants followed by I_2, then I_3. In the sand soil, slight insignificant greater uptake occurred with I_1 plants as compared with I_2 and I_3 plants, which were similar in uptake. Therefore the effect of irrigation interval was not the same in each soil, i.e., soil-interval interaction.

In the clay soil, I_2 gave 79.1 % and I_3 gave 20.1 % greater increase in P-uptake over that of the I_1 treatment. In the sandy clay soil, I_2 and I_3 gave decreases of 30.0 % and 51.2 % respectively under that of I_1.

In the sand soil, both I_2 and I_3 showed a slight 3.8 % decrease under I_1. Decreasing irrigation interval to 3 days in the clay soil may have been associated with a decrease in aeration of the root medium, reflected in a lower P-uptake as compared with the 6-day interval. An increase in the interval to 9-days in the same soil may have caused a moisture stress causing a lower P-uptake as compared with the 6-day interval. Therefore, in this particular heavy soil the intermediate I_2 interval was the most appropriate for P-uptake; and the shortest interval seemed to have caused the most adverse conditions for plant growth and consequently nutrients uptake, as compared with the medium and long intervals. Results of the yield of straw + grains confirms this (see Table 4). Low aeration and possible retardation of root growth due to excess water of the I_1-treatment in such a heavy clay soil must have occurred. However, in the medium texture soil (S_2), the I_1-treatment gave the highest P-

Table (8): Effect of irrigation intervals with using light and heavy soils on P-uptake by total yield (grains + straw) mg P/pot of wheat irrigated with saline water (3.59 dS/m).

Soil [S]	Irrigation intervals (day) [I]			
	3-day (I_1)	6-day (I_2)	9-day (I_3)	Mean
Clay (S_1)	9.47	16.96	11.37	12.60
Sandy clay (S_2)	12.90	9.03	6.30	9.41
Sand (S_3)	2.06	1.98	1.98	2.01
Mean	8.14	9.32	6.55	
LSD (0.05):	I = 1.34	S = 1.34	I × S = 2.31	
LSD (0.01):	I = 1.83	S = 1.83	I × S = 3.17	

Table (9): Effect of irrigation intervals with using light and heavy soils on K-uptake by total yield (grains + straw) mg K/pot of wheat irrigated with saline water (3.59 dS/m).

Soil [S]	Irrigation intervals (day) [I]			
	3-day (I_1)	6-day (I_2)	9-day (I_3)	Mean
Clay (S_1)	136.2	134.1	291.7	187.3
Sandy clay (S_2)	87.6	106.4	283.4	159.1
Sand (S_3)	9.9	16.2	21.5	15.9
Mean	77.9	85.6	198.9	
LSD (0.05):	I = 3.05	S = 3.05	I × S = 5.27	
LSD (0.01):	I = 4.19	S = 4.19	I × S = 7.25	

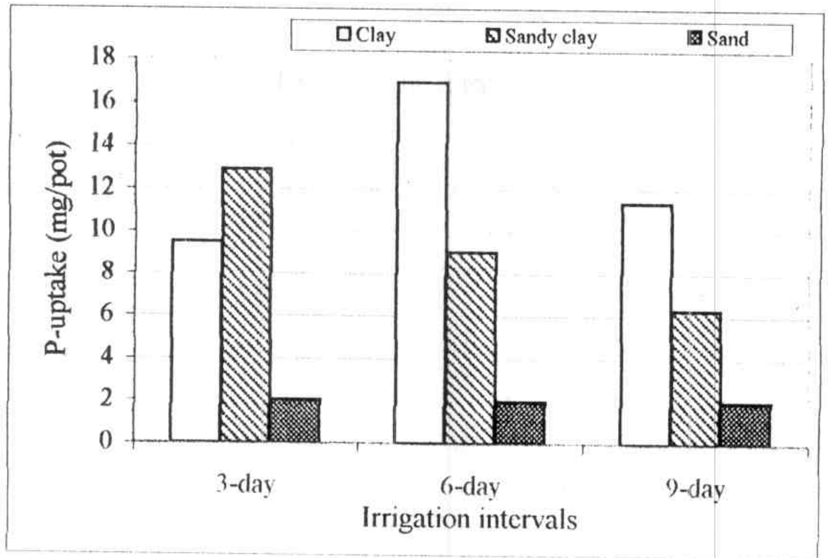

Fig. (5): Relationship between P-uptake and irigation intervals.

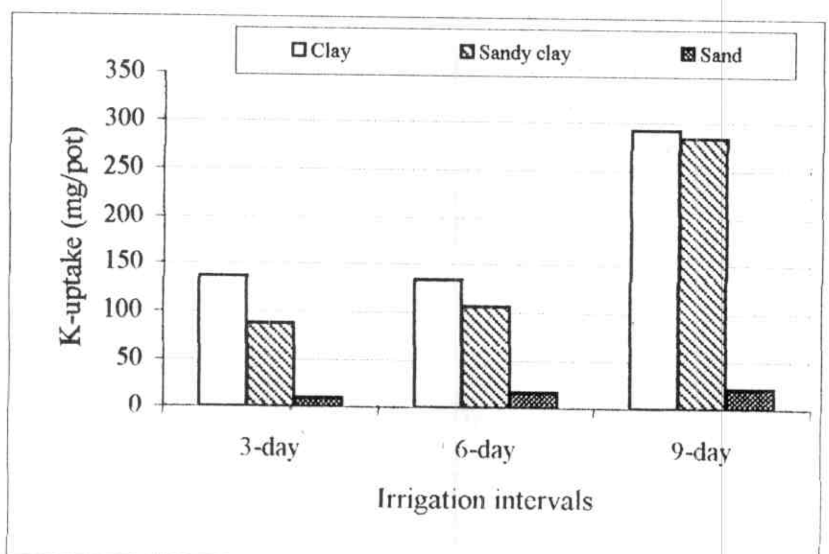

Fig. (6): Relationship between K-uptake and irigation intervals.

uptake; retaining moisture and aeration conditions in this soil to enhance P-availability. **El-Sharawy et al. (1998)** reported increased P-availability with optimal moisture in soil.

K-uptake by total yield "Table 9 and Fig. 6":

K-uptake by the total yield increased by increasing the interval period between irrigations. Average increases were 9.9 % and 155.3 % using the 6-day (I_2) and 9-day (I_3) intervals, respectively, as related to the use of 3-day interval (I_1). Such a pattern was particularly true in the medium textured (S_2) and the coarse textured (S_3) soils. In the fine textured (S_1), clay soil increasing the interval from I_1 to I_2 did not affect K-uptake. Therefore, moisture stress was most pronounced in the lighter soils involving increased K-uptake.

Decreasing the period between irrigations may have led to a less of soil K. Water-soluble K in the short-interval treatment of the clay soil was lower than in the long-interval treatments (see Table 8-Appendix 1 of soluble K in soil). **Abo El-Defan (1990)** reported positive results in plant growth due to decreasing intervals between irrigations of wheat. In the clay soil (S_1), K-uptake by the 3-day and by the 6-day intervals were lower than that by the 9-day interval by 53.3 % and 54.0 %, respectively. In the sand soil (S_3), comparable percentages were 53.95 % and 24.65 %, respectively.

N-uptake by grains "Table 10 and Fig. 7":

N-uptake by grains increased by increasing the interval period between irrigations. The increase was greatest using the 6-day interval (I_2). Average increases were 54.0 % and 26.2 % using 6-day (I_2) and 9-day (I_3) intervals, respectively, related to

Table (10): Effect of irrigation intervals with using light and heavy soils on N-uptake by grain yield (mg N/pot) of wheat irrigated with saline water (3.59 dS/m).

Soil [S]	Irrigation intervals (day)			[I]
	3-day (I_1)	6-day (I_2)	9-day (I_3)	Mean
Clay (S_1)	194	364	313	290
Sandy clay (S_2)	281	371	291	314
Sand (S_3)	29	39	32	33
Mean	168	258	212	
LSD (0.05):	I = 4	S = 4	I ×S = 6	
LSD (0.01):	I = 8	S = 8	I × S = 13	

Table (11): Effect of irrigation intervals with using light and heavy soils on N-uptake by straw yield (mg N/pot) of wheat irrigated with saline water (3.59 dS/m).

Soil [S]	Irrigation intervals (day)			[I]
	3-day (I_1)	6-day (I_2)	9-day (I_3)	Mean
Clay (S_1)	127	149	186	154
Sandy clay (S_2)	214	217	100	177
Sand (S_3)	22	26	24	24
Mean	121	131	103	
LSD (0.05):	I = 3	S = 3	I ×S = 4	
LSD (0.01):	I = 5	S = 5	I × S = 9	

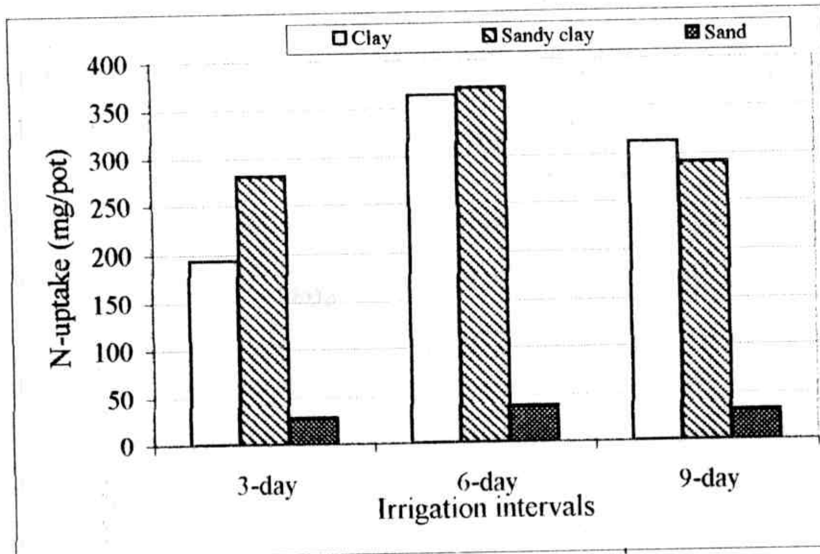

Fig. (7): Relationship between N-uptake by grain yield and irigation intervals.

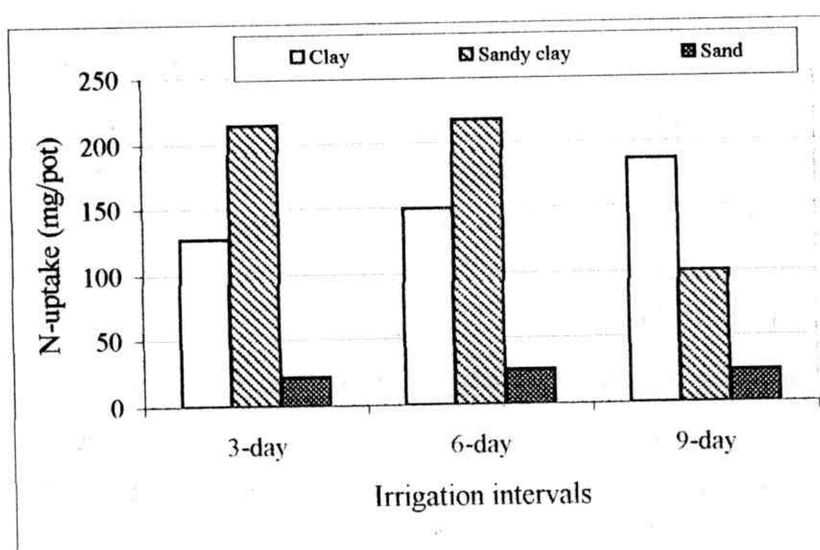

Fig. (8): Relationship between N-uptake by straw yield and irigation intervals.

the use of 3-day interval (I_1). Both I_2 and I_3 gave significantly higher N-uptake than I_1. N-uptake by I_2 was greater than N-uptake by I_3. The 3-day interval gave the lowest N-uptake in grains and the 6-day interval gave the highest N-uptake by the grain yield. 9-day interval gave lower N-uptake by the grain yield than by 6-day interval. Moderate irrigation interval (6-day interval) therefore was the most appropriate one for N-uptake by grains yield. In the clay soil (S_1), N-uptake values using the 3-day and the 9-day intervals were lower by 46.70 % and 14.01 %, respectively compared with the 6-day interval. In the sand soil (S_3), comparable percentages were 25.64 % and 17.95 %, respectively.

<u>N-uptake by straw "Table 11 and Fig. 8":</u>

The pattern of response to irrigation interval depended on the soil texture, i.e., soil texture caused an interaction with irrigation interval. In the clay soil (S_1), increased interval was associated with increased N-uptake and I_2 and I_3 showed progressive increases of 17.3 and 46.5 % relative to I_1. In the other two soils (S_2 & S_3), which are coarser than S_1, there was an increase at I_2 followed by a decrease at I_3, i.e., the highest N-uptake was given by I_2. In the medium-textured soil (S_2), the longest interval I_3 caused a considerable decrease in N-uptake, nearly half the uptake at I_1 or I_2.

<u>P-uptake by grains "Table 12 and Fig. 9":</u>

Under conditions of the clay soil (S_1) the highest P-uptake by grains was realized by I_3 followed by I_1 and the lowest P-uptake occurred with I_1. Under conditions of the sandy clay soil (S_2), the highest P-uptake by grains was obtained with I_1

followed by I_2, then by I_3. Under conditions of the sand soil, all of the 3 treatments were rather similar with no significant difference between them. Therefore treatment giving the highest P-uptake was I_2 in the clay soil where it showed about 2.5 times as much uptake as given by I_1. In the sandy clay soil, I_1 gave the highest P-uptake exceeding I_2 (by about one-fifth), and I_3 (by about four-fifths). In all soils, long period between irrigations is reflected in lower P-uptake.

Increasing the period between irrigations using saline water would increase moisture tension and consequently accentuate the salinity effect decreasing availability of P. **FAO (1985)** pointed out that the retarding effect of saline waters on plants takes time and visual damage is often slow to be noticed. **El-Sharawy et al. (1998)** reported the lowest values of macronutrients uptake in grains and straw were found in wheat plants, which were irrigated with water of about 10 dS/m. The very short period between irrigations (I_1) was thus not suitable for the clay soil in particular. It may have caused some restriction in soil aeration around plant root.

P-uptake by straw "Table 13 and Fig. 10":

P-uptake by straw yield decreased by increasing the interval period between irrigations particularly with the sandy clay soil (S_2). The average values of P uptake over the 3 soils for I_2 and I_3 was lower by 26.4 % and 36.2 %, respectively, in comparison with (I_1).

Therefore, the 3-day interval gave the highest P-uptake by straw yield as compared either with 6-day or with 9-day intervals, where no significant difference was noticed between 6-

Table (12): Effect of irrigation intervals with using light and heavy soils on P-uptake by grain yield (mg P/pot) of wheat irrigated with saline water (3.59 dS/m).

Soil [S]	Irrigation intervals (day) [I]			
	3-day (I_1)	6-day (I_2)	9-day (I_3)	Mean
Clay (S_1)	4.86	12.06	7.09	8.00
Sandy clay (S_2)	7.75	6.47	4.23	6.15
Sand (S_3)	1.02	0.99	1.02	1.01
Mean	4.54	6.51	4.11	
LSD (0.05):	I = 0.51	S = 0.51	I ×S = 0.89	
LSD (0.01):	I = 1.06	S = 1.06	I × S = 1.83	

Table (13): Effect of irrigation intervals with using light and heavy soils on P-uptake by straw yield (mg P/pot) of wheat irrigated with saline water (3.59 dS/m).

Soil [S]	Irrigation intervals (day) [I]			
	3-day (I_1)	6-day (I_2)	9-day (I_3)	Mean
Clay (S_1)	5.27	4.89	4.29	4.82
Sandy clay (S_2)	5.15	2.56	2.07	3.26
Sand (S_3)	1.04	0.99	0.96	1.00
Mean	3.82	2.81	2.44	
LSD (0.05):	I = 0.48	S = 0.48	I ×S = 0.83	
LSD (0.01):	I = 0.99	S = 0.99	I × S = NS	

NS = not significant

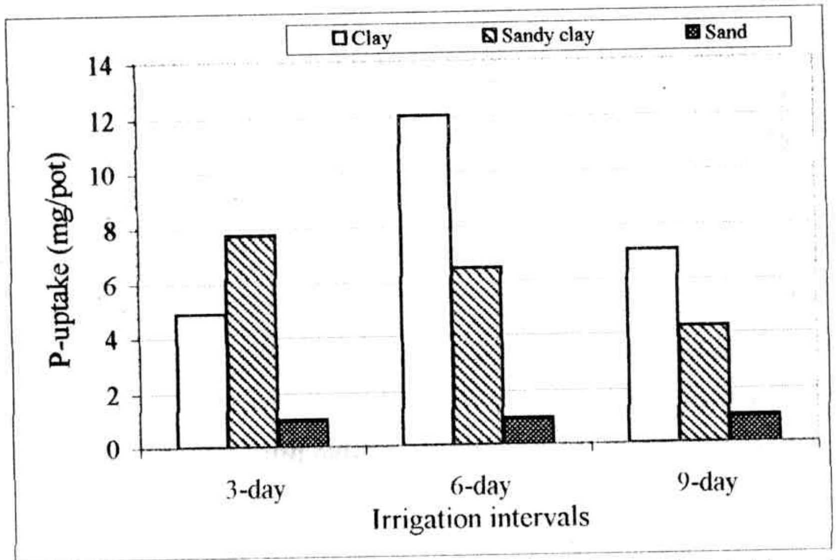

Fig. (9): Relationship between P-uptake by grain yield and irigation intervals.

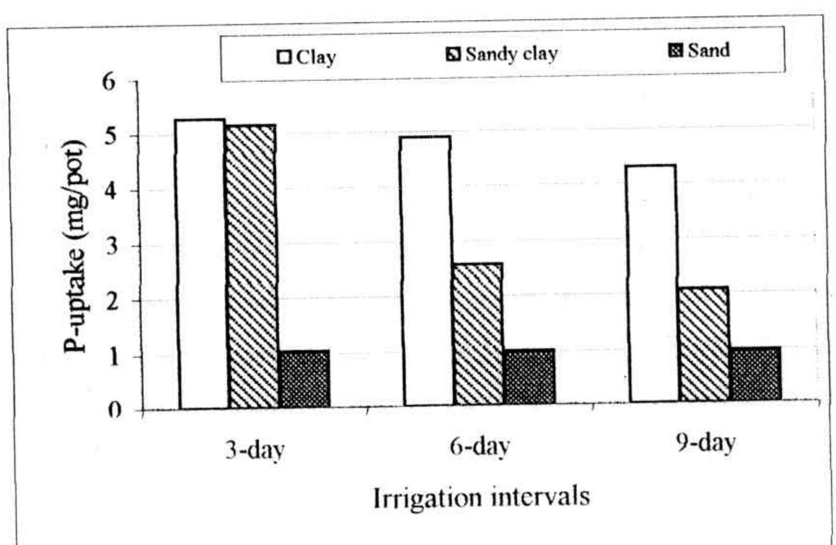

Fig. (10): Relationship between P-uptake by straw yield and irigation intervals.

day and 9-day intervals. **Mohamed (1987)** attributed the positive correlation between available P and soluble salts in the soil to a possible solubilization of P under the effect of sodium salts especially chlorides and sulphates. On the other hand, increased moisture in soil associated with the low-irrigation frequency may have contributed to increased P-availability. **Curtin et al. (1992)** studied the effect of salinity and sodicity of irrigation water on solubility of native P in some soils, and found that leached P decreased as salinity as well as sodicity of irrigation water increased. The high P-uptake obtained by the low frequency irrigation was most marked with the clay soil. However, in the sand soil, there were no significant differences between the three intervals as for P-uptake by straw yield reflecting the very low fertility of this particular soil.

<u>K-uptake by grains "Table 14 and Fig. 11":</u>

Increased the period between irrigations was associated with increased K-uptake by grains. The increase was greatest (a double-fold) with the 9-day interval (I_3). Values of average increases were 28.6 % and 200.9 % using 6-day (I_2) and 9-day (I_3) intervals, respectively, as related to the use of the 3-day interval (I_1). The magnitude of increase was much greater in the sandy clay soil, indicating a much severe stress of salinity and moisture in this soil as compared with the clay or sand soil. The increased K-uptake, which was associated with increased interval between irrigations, is due to increased K-concentration in plant tissues, more than to increased plant growth (see Table 4).

Table (14): Effect of irrigation intervals with using light and heavy soils on K-uptake by grain yield (mg K/pot) of wheat irrigated with saline water (3.59 dS/m).

Soil [S]	Irrigation intervals (day) [I]			
	3-day (I_1)	6-day (I_2)	9-day (I_3)	Mean
Clay (S_1)	78.7	95.9	182.9	119.2
Sandy clay (S_2)	49.8	67.2	209.6	108.9
Sand (S_3)	6.0	9.7	12.0	9.2
Mean	44.8	57.6	134.8	
LSD (0.05):	I = 1.41	S = 1.41	I ×S = 2.44	
LSD (0.01):	I = 2.91	S = 2.91	I × S = 5.04	

Table (15): Effect of irrigation intervals with using light and heavy soils on K-uptake by straw yield (mg K/pot) wheat irrigated with saline water (3.59 dS/m).

Soil [S]	Irrigation intervals (day) [I]			
	3-day (I_1)	6-day (I_2)	9-day (I_3)	Mean
Clay (S_1)	57.5	38.2	108.8	68.2
Sandy clay (S_2)	37.8	39.2	73.8	50.3
Sand (S_3)	3.9	6.6	9.4	6.6
Mean	33.1	28.0	64.0	
LSD (0.05):	I = 1.49	S = 1.49	I ×S = 2.57	
LSD (0.01):	I = 3.07	S = 3.07	I × S = 5.32	

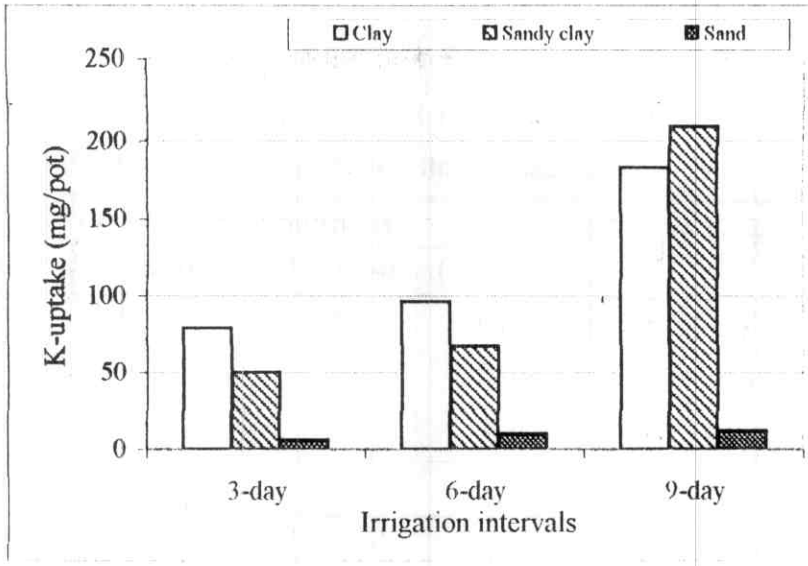

Fig. (11): Relationship between K-uptake by grain yield and irigation intervals.

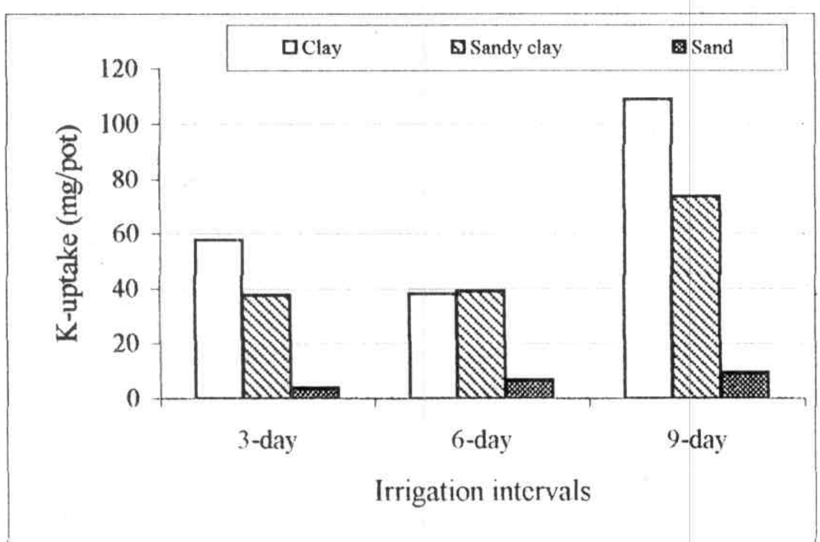

Fig. (12): Relationship between K-uptake by straw yield and irigation intervals.

Using the 9-day interval gave the highest K-uptake by grain yield, and using the 3-day interval gave the lowest K-uptake by the grain yield. In the clay soil, the higher K-uptake in grains using 6-day and 9-day intervals were 21.9 % and 132.4 %, respectively in comparison with using the 3-day interval. In the sandy clay soils, comparable values were 34.9 % and as high as 321 %, respectively. Comparable values for the sand soil were 61.7 % and 100 %, respectively.

K-uptake by straw "Table 15 and Fig. 12":

There was a general trend of increased K-uptake with increased interval between irrigations. Average K-uptake was 39.0 % greater using the I_3 treatment over the I_1 treatment. **Anter (1963), Mahrous et al. (1983), Devitte et al (1981)** and **El-Toukhy (1987)** reported that high salinity in soil was associated with high contents of water soluble as well as ammonium acetate extractable K. In the clay soil, values of K-uptake by straw using 3-day and 6-day intervals were respectively 47.2 % and 64.9 % lower in comparison with the 9-day interval. In the sand soil, no significant differences between either the 3-day and the 6-day intervals or the 6-day and the 9-day intervals.

EC of soil paste extract "Table 3 of appendix 1 and Fig. 13":

Values of EC were measured at end of experiment. The general trend of salinity before start of experiment and its end shows a decrease in salinity (compare table 1 with table 3 of Appendix 1).

EC of soil paste extract increased by increasing the interval period between irrigations, however, the highest EC was obtained in most cases in soil of the 6-day (I_2) interval. In the

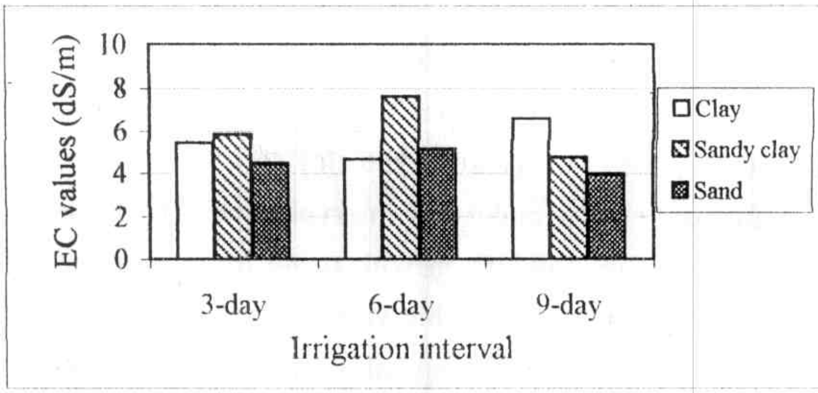

Fig. (13): Interaction between irrigation intervals and soil type on EC of soil paste extract.

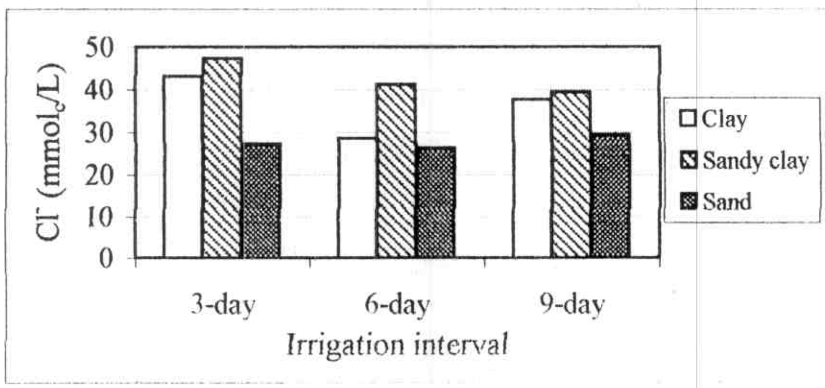

Fig. (14): Interaction between irrigation intervals and soil type on soluble Cl^- of soil paste extract.

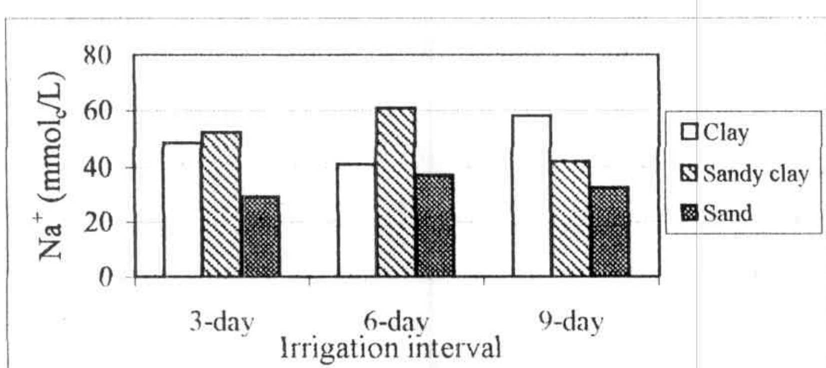

Fig. (15): Interaction between irrigation intervals and soil type on soluble Na^+ of soil paste extract.

sand soil, the lowest EC was that of I_3 interval. This trend was most marked in the sandy clay soil (S_2) and in the sand soil (S_3). In S_2, there were 23.53 and 38.04 % decreases in salinity at I_1 and I_3 in comparison with at I_2. In S_3, decreases were 12.84 and 22.76 %, respectively. In S_1, decreases were 17.60 and 29.29 %, respectively.

Soluble Cl^- of soil paste extract "Table 5 of appendix 1 and Fig. 14":

Values of soluble Cl^- were measured at end of experiment. The general trend of soluble Cl^- before start of experiment and its end shows a reduction in soluble Cl^- (compare table 1 with table 5 of Appendix 1).

Soluble chloride decreased by increasing the interval period between irrigations. The lowest decrease in Cl^- ion of soil paste extract occurred at I_2. Soluble Cl^- obtained at I_3 irrigation interval was lower than at I_1. Decreases were 18.38 and 9.80 % at I_2 and I_3, respectively in comparison with I_1. This trend was most marked in the clay soil (S_1), where the decreases were 33.79 and 12.88 % at I_2 and I_3, respectively. In the sandy clay soil (S_2), decreases were 12.89 and 16.87 % at I_2 and I_3, respectively. In the sand soil (S_3), the decrease was slight.

Soluble Na^+ of soil paste extract "Table 7 of appendix 1 and Fig. 15":

Values of soluble Na^+ were measured at end of experiment. The general trend of soluble Na^+ before start of experiment and its end shows a decrease in soluble Na^+ (compare table 1 with table 7 of Appendix 1).

Soluble Na^+ of soil paste extract was lower at I_1 and I_3 than at I_2. The lowest was at I_1. At I_1 and I_3, soluble Na^+ was lower by average of 6.50 and 4.50 % in comparison with I_2. This pattern was most marked in the sand soil with 20.98 and 12.66 % lower values at I_1 and I_3, respectively in comparison with I_2. In the sandy clay soil, comparable values were 30.53 and 14.25 %, respectively. In the clay soil, values were 16.47 and 29.30 %, respectively.

<u>Conclusive assessment on results of experiment 1, effect of irrigation interval on alleviating salinity stress:</u>

Increased intervals between irrigations using saline water would involve increased stress on plant growth; such stress would be drought stress coupled with stress due to increased salinity. This incurs a reduction of plant growth and plant yield. On the other hand, although decreased intervals may alleviate salinity stress and may not lead to build-up of salinity in the soil, it may cause a negative effect on plant growth. This negative effect may arise from one or more of the followings:

(a) A severe loss of nutrients due to leaching.

(b) An adverse effect due to excess moisture and restricted aeration.

(c) Possible conditions of the denitrification due to excess moisture.

Therefore, an optimum irrigation frequency so as to avoid drought and increased salinity, as well as avoiding excessive losses by leaching and also avoiding anaerobic conditions is essential to obtain optimum growth and production (yield). The nature of the soil is also of great importance. For example a soil such as a sandy clay soil may not show severe negative anaerobiosis when irrigation frequently as compared with a heavier soil such as the clay soil.

Experiment 2: gypsum addition

In this experiment, two gypsum addition rates were used, i.e., equivalent to 2 (R_1) and 4 (R_2) tons "Mg" metric ton, i.e., 4 Mg/fed "megagram "Mg" = 10^6 g" of gypsum/feddan, respectively under conditions of using very-high salinity "W1: 3.59 dS/m" and excessively-high salinity "W2: 7.18 dS/m" waters for irrigation and 3 soils. The objective of this study is evaluating the effect of adding gypsum. Wheat plant Sakha 93 was used as an indicator plant.

Total yield " Table 16 and Fig. 16"

Addition of gypsum increased total yield, but no significant deference was found between the total yield obtained by the 2 or 4 ton gypsum/fed. Both 2 and 4 ton/fed of gypsum addition rates gave significantly higher total yields than the no addition treatment. The average increases were 24.12 % and 23.55 % using 2 and 4 ton gypsum/fed, respectively. The pattern of response to gypsum addition was under conditions of irrigation with the two waters. The pattern of response was particularly evident with the clay soil (S_1) giving 34.7 % and 42.6 % increase upon adding R_1 and R_2, respectively. For the sandy clay soil (S_2) and the sand soil (S_3), R_1 and R_2 showed increases of 14.33 % and 4.75 %, respectively for S_2 and 11.24 % and 4.84 %, respectively for S_3. Thus, the positive effect of gypsum addition in reducing salinity stress was more effective in the heavy soils. Application of gypsum to the clay soil under conditions of irrigation with W_1 (the lower salinity water) gave significant positive effect at R_1 and R_2. However, with W_2 (the higher salinity water), the total yields of R_1 or of R_2 were nearly

Table (16): Effect of gypsum addition under conditions of irrigation with very-high salinity and excessively-high salinity waters on total yield (grains + straw) g/pot applied to wheat grown on light and heavy soils.

Soil [S]	Water salinity [W]	Rate of gypsum (ton/feddan) [R]			
		0	2	4	Mean
Clay	W_1	22.79	36.12	40.50	33.14
	W_2	34.11	40.53	40.62	38.42
	Mean	28.45	38.33	40.56	35.78
Sandy clay	W_1	22.64	23.33	24.06	23.34
	W_2	24.52	30.58	25.34	26.75
	Mean	23.58	26.96	24.70	25.08
Sand	W_1	2.95	6.02	5.57	4.85
	W_2	7.37	5.46	5.24	6.02
	Mean	5.16	5.74	5.41	5.44
		Means of water salinity treatments			
	W_1	16.13	21.82	23.38	20.44
	W_2	22.00	25.52	23.73	23.75
Grand mean		19.07	23.67	23.56	22.10

LSD (0.05):
S=0.19; W=0.16; R=0.19; WR=0.27; WS=0.27; RS=0.34; WRS=0.48

LSD (0.01):
S=0.26; W=0.21; R=0.26; WR=0.37; WS=0.37; RS=0.45; WRS=0.64

W_1 = 3.59; W_2 = 7.18 dS/m

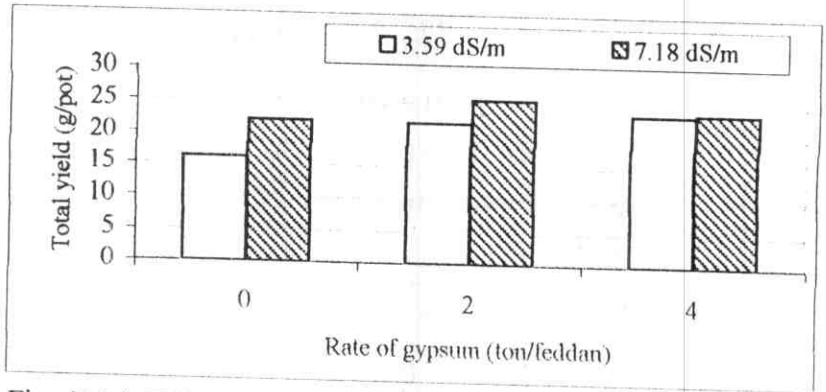

Fig. (16a): Effect of the interaction between addition rates of gypsum and water salinity on total yield.

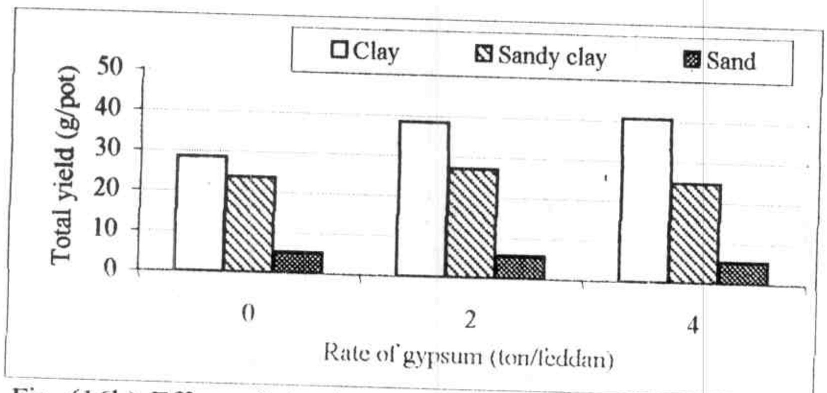

Fig. (16b): Effect of the interaction between addition rates of gypsum and soil type on total yield.

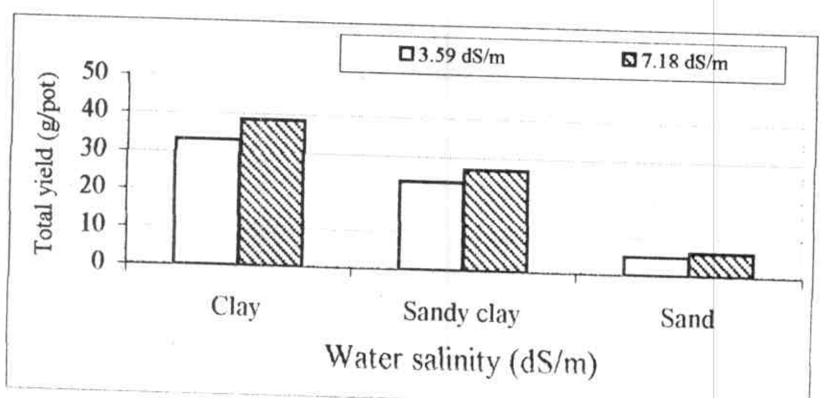

Fig. (16c): Effect of the interaction between water salinity and soil type on total yield the same. Therefore efficiency of gypsum was of a progressive nature under lower salinity irrigation water (W_1).

As solubility of the gypsum increases under conditions of using saline water for irrigation due to a release of more Ca^{++} iòns **(Abdel-Salam and El-Sanat, 2003)** which may have overcome the harmful effect of Na^+ ion and enhance nutrients availability to plants for more growth. In the sandy clay soil, application of gypsum under conditions of irrigation with W_1 gave significant positive effect of progressive increase in total yield; and under using W_2 for irrigation with R_2 gave the highest total yield.

In the sand soil, addition of gypsum under conditions of irrigation with W_1 has a positive effect either with R_1 or R_2 of gypsum addition rates; while with W_2 it showed a negative effect under both rates of R_1 and R_2 and this indicates that, gypsum addition to coarse texture has little effect for reducing salinity stress.

Grain yield "Table 17 and Fig. 17"

Application of gypsum increased yields of grains. The increase was progressive with increased application of gypsum. The average increases in yield were 22.7 % and 29.9 % upon applying R_1 and R_2, respectively. The pattern of response to gypsum application occurred under conditions of irrigation with the two waters. The pattern of response was particularly evident with the clay soil and the sandy clay soil where R_1 and R_2 showed marked increases of 30.2 % and 35.0 %, respectively and 16.5 % and 25.3 %, respectively for the latter soil. In the sand soil, however, R_2 was the only effective rate for increasing

Table (17): Effect of gypsum addition under conditions of irrigation with very-high salinity and excessively-high salinity waters on grain yield (g/pot) applied to wheat grown on light and heavy soils.

Soil [S]	Water salinity [W]	Rate of gypsum (ton/feddan) [R] 0	2	4	Mean
Clay	W_1	12.73	18.22	19.51	16.82
	W_2	15.89	19.04	19.12	18.02
	Mean	14.31	18.63	19.32	17.42
Sandy clay	W_1	10.33	13.93	15.04	13.10
	W_2	11.50	11.51	12.32	11.78
	Mean	10.92	12.72	13.68	12.44
Sand	W_1	1.58	1.92	1.98	1.83
	W_2	2.34	2.09	2.65	2.36
	Mean	1.96	2.01	2.32	2.10
		Means of water salinity treatments			
	W_1	8.21	11.36	12.18	10.58
	W_2	9.91	10.88	11.36	10.72
Grand mean		9.06	11.12	11.77	

LSD (0.05):

S=0.20; W=NS; R=0.20; WR=0.27; WS=0.27; RS=0.33; WRS=0.47

LSD (0.01):

S=0.26; W=NS; R=0.26; WR=0.36; WS=0.36; RS=0.45; WRS=0.63

W_1 = 3.59; W_2 = 7.18 dS/m

*NS = not significant

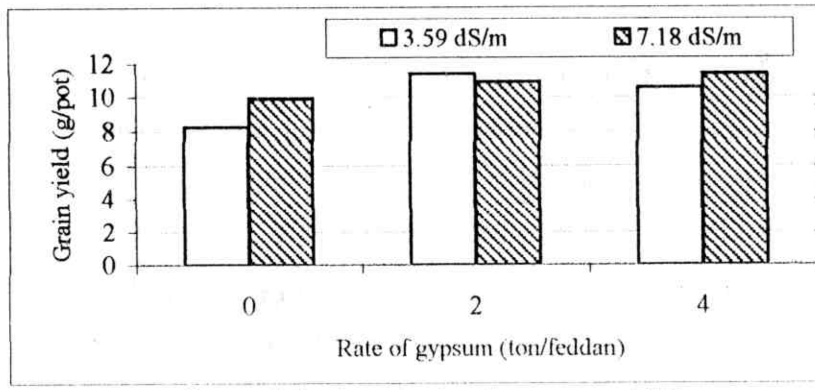

Fig. (17a): Effect of the interaction between addition rates of gypsum and water salinity on grain yield

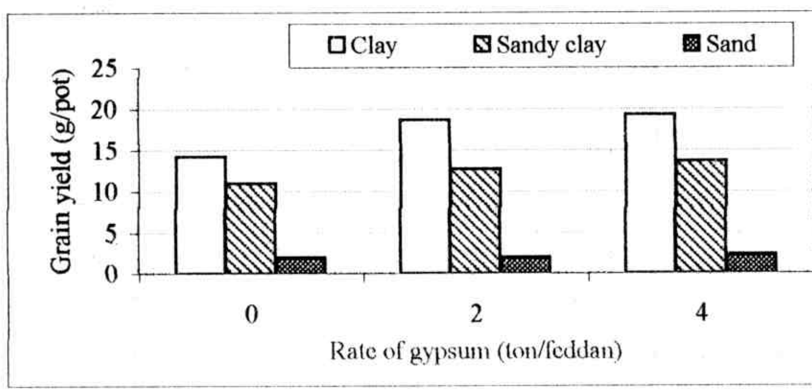

Fig. (17b): Effect of the interaction between addition rates of gypsum and soil type on grain yield

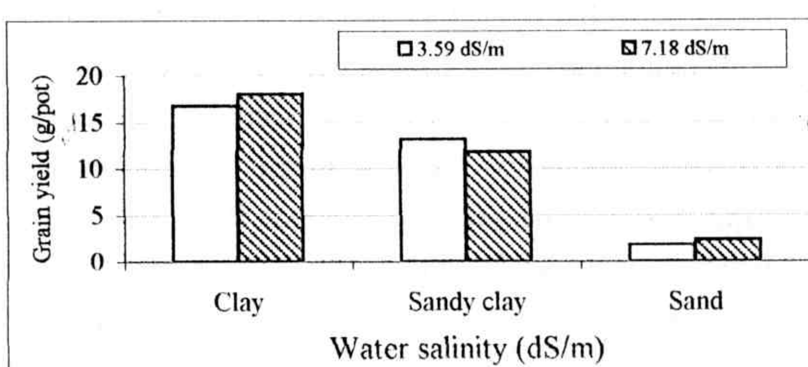

Fig. (17c): Effect of the interaction between water salinity and soil type on grain yield grain yield giving 18.4 % significant (only at 0.05 probability); the 2.6 % increase due to R_1 was not statistically significant. Therefore the positive effect of gypsum application in alleviating salinity stress was more effective in the heavy soils.

Application of gypsum to the sand soil under conditions of irrigation with the lower salinity water (W_1) was not effective at all gypsum rates. Under conditions of irrigation with the higher salinity water (W_2) a positive significant effective occurred at the highest rate of gypsum.

It could be concluded that, addition of gypsum under condition of irrigation with water of 7.18 dS/m in clay or heavy soils may result in alleviating salinity stress effect on wheat plant and obtain higher grain yields. As solubility of gypsum increases with increasing salinity of irrigation water, hence, the release of Ca^{++} ions increase, which can overcome the harmful effect of Na^{+} ions and enhance availability of nutrients to plant uptake for better growth **(Abdel-Salam and El-Sanat, 2003)**.

Straw yield "Table 18 and Fig. 18"

Straw yield increased with gypsum application, however, the highest average straw yield was obtained at gypsum addition rate of 2 ton/fed (R_1). The average increases were 25.60 % and 17.90 % upon applying R_1 and R_2, respectively. Such a pattern of response to gypsum application occurred under conditions of irrigation with the two waters. Response to gypsum application in the clay soil was progressive since R_1 and R_2 showed marked increases of 39.32 % and 50.28 %, respectively. In the sandy clay and sand soils, however, R_1 was the only effective rate for increasing straw yield giving 12.39 % in sandy clay soil and

Table (18): Effect of gypsum addition under conditions of irrigation with very-high salinity and excessively-high salinity waters on straw yield (g/pot) applied to wheat grown on light and heavy soils.

Soil [S]	Water salinity [W]	Rate of gypsum (ton/feddan) [R]			
		0	2	4	Mean
Clay	W_1	10.06	17.90	20.99	16.32
	W_2	18.22	21.49	21.50	20.40
	Mean	14.14	19.70	21.25	18.36
Sandy clay	W_1	12.31	9.40	9.02	10.24
	W_2	13.02	19.07	13.02	15.04
	Mean	12.67	14.24	11.02	12.64
Sand	W_1	1.36	4.10	3.59	3.02
	W_2	5.03	3.37	2.59	3.66
	Mean	3.20	3.74	3.09	3.34
		Means of water salinity treatments			
	W_1	7.91	10.47	11.20	9.86
	W_2	12.09	14.64	12.37	13.03
Grand mean		10.00	12.56	11.79	

LSD (0.05):

S=0.01; W=0.007; R=0.01; WR=0.013; WS=0.0.13; RS=0.017; WRS=0.023

LSD (0.01):

S=0.013; W=0.01; R=0.013; WR=0.018; WS=0.018; RS=0.022; WRS=0.032

W_1 = 3.59; W_2 = 7.18 dS/m

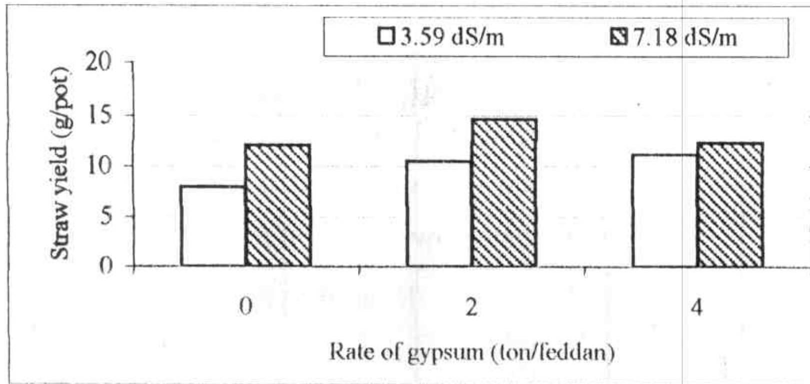

Fig. (18a): Effect of the interaction between addition rates of gypsum and water salinity on straw yield

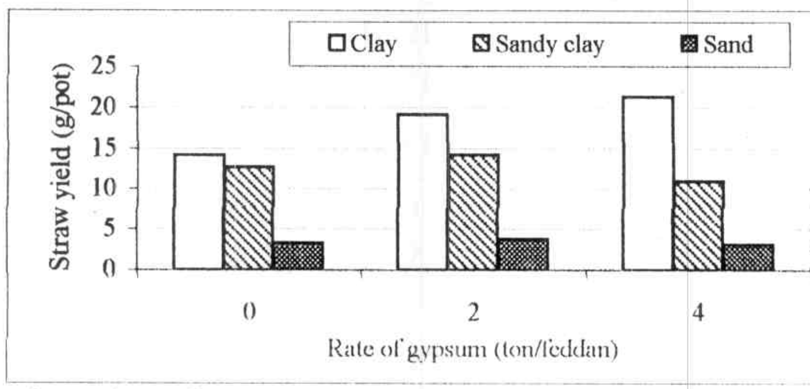

Fig. (18b): Effect of the interaction between addition rates of gypsum and soil type on straw yield

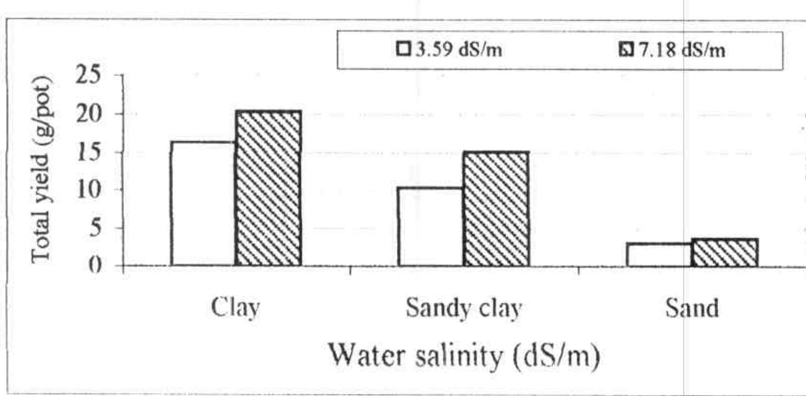

Fig. (18c): Effect of the interaction between water salinity and soil type on straw yield

16.88 % in sand soil. Therefore, the positive effect of gypsum application in decreasing salinity stress was more effective in the heavy soil (clay soil). Addition of gypsum to the sandy clay soil under conditions of irrigation with the lower salinity water (W_1) was not effective, whereas under conditions of W_2, at R_1 was the only positive significant effect occurred. Applications of irrigation with the lower salinity water (W_1) was particularly effective at all its rates. Under conditions of irrigation with the higher salinity water (W_2), gypsum addition showed a slight positive effect. This reflects the lower effectiveness of gypsum addition in the sand soils to reduce salinity stress.

N-uptake by total yield "Table 19 and Fig. 19"

Application of gypsum leads to decrease N-uptake by total yield. Decrease in N-uptake by total yield was greater with R_1 gypsum addition rate than with R_2. The average decreases in N-uptake by total yield were 12.57 % and 4.06 % upon applying R_1 and R_2, respectively. The pattern of non-response to gypsum application occurred under condition of irrigation with W_2 (higher salinity), however, the only positive effect for increasing response to N-uptake by total plant occurred under irrigation with W_1 (lower salinity) upon applying R_2 gypsum addition rate. The pattern of non-response was particularly evident with the sandy clay soil and the sand soil, where R_1 and R_2 showed marked decreases of 24.85 % and 16.37 %, respectively and 6.06 % and 18.18 %, respectively for the latter soil. In clay soil, however, R_2 was the only effective rate for increasing N-uptake by the total yield giving 8.61 %. Thus, the positive effect of

Table (19): Effect of gypsum addition under conditions of irrigation with very-high salinity and excessively-high salinity waters on N-uptake (mg/pot) by total yield (grain + straw) applied to wheat grown on light and heavy soils.

Soil [S]	Water salinity [W]	Rate of gypsum (ton/feddan) [R]			
		0	2	4	Mean
Clay	W_1	672	796	960	809
	W_2	884	718	729	777
	Mean	778	757	845	793
Sandy clay	W_1	688	469	652	603
	W_2	656	541	472	556
	Mean	672	505	562	580
Sand	W_1	67	93	71	77
	W_2	130	92	91	104
	Mean	99	93	81	91
		Means of water salinity treatments			
	W_1	476	453	561	497
	W_2	557	450	431	479
Grand mean		517	452	496	

LSD (0.05):

S=5.02; W=4.10; R=5.02; WR=7.10; WS=7.10; RS=8.70; WRS=12.30

LSD (0.01):

S=6.73; W=5.50; R=6.73; WR=9.52; WS=9.52; RS=11.66; WRS=16.49

W_1 = 3.59; W_2 = 7.18 dS/m

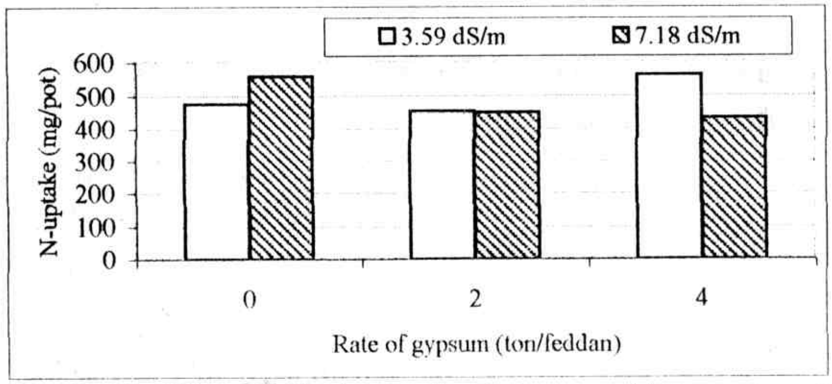

Fig. (18a): Effect of the interaction between addition rates of gypsum and water salinity on N-uptake by total yield

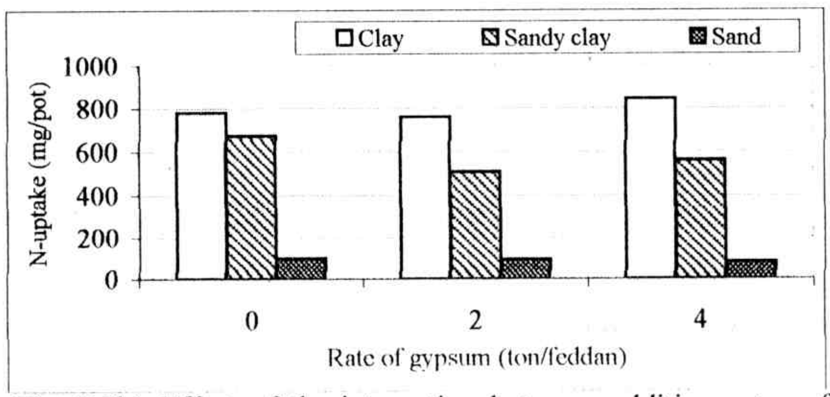

Fig. (18b): Effect of the interaction between addition rates of gypsum and soil type on N-uptake by total yield

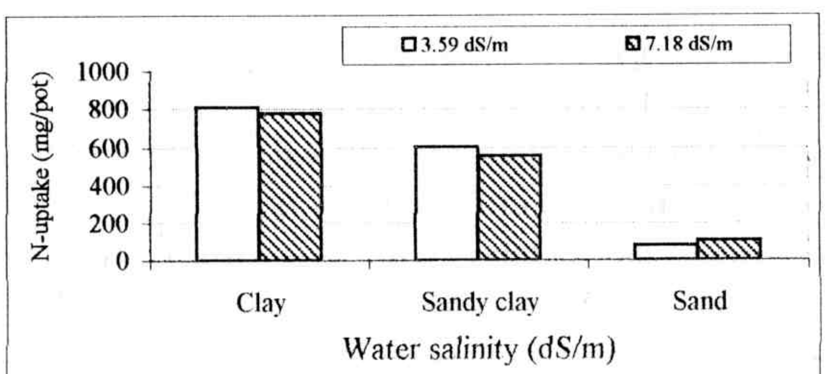

Fig. (18c): Effect of the interaction between water salinity and soil type on N-uptake by total yield gypsum application in alleviating salinity stress was more effective in the heavy soil (clay soil).

Application of gypsum to the clay soil under condition of irrigation with the lower salinity water (W_1) was effective at all the addition rates of gypsum, also this trend was clearly evident in sand soil under condition of irrigation with the lower salinity water (W_1), where it was effective at 2 ton/fed gypsum addition rate only. It could be concluded that adding gypsum with using lower salinity water (3.59 dS/m) at 4 ton gypsum/fed is consider a favourable practice to give the highest N-uptake by plant.

Aforementioned was in a good agreement with **Abou El-Defan et al. (1999),** who applied gypsum up to 4 ton/fed and obtained increased contents of available N, P and K in soil; also, contents of such nutrients in grain which increased by gypsum application.

P-uptake by total yield "Table 20 and Fig. 20"

Application of gypsum did not give any significant effective results at all its rates about P-uptake by the total yield. Also, there was no significant response to gypsum application under conditions of irrigation with the two waters. The response to gypsum application was positive only with the clay soil, where R_1 and R_2 showed marked increases of 12.93 % and 20.94 %, respectively. In the sandy clay and sand soils, there was no significant response to the gypsum application at all its rates. Therefore, the positive effect of gypsum application in decreasing salinity stress was more effective in the clay soil. In this particular soil, application of gypsum under conditions of irrigation with the lower salinity water (W_1) was effective at all

Table (20): Effect of gypsum addition under conditions of irrigation with very-high salinity and excessively-high salinity waters on P-uptake (mg/pot) by total yield (grains + straw) applied to wheat grown on light and heavy soils.

Soil [S]	Water salinity [W]	Rate of gypsum (ton/feddan) [R]			
		0	2	4	Mean
Clay	W_1	24.26	29.59	26.61	26.82
	W_2	25.22	26.28	33.22	28.24
	Mean	24.74	27.94	29.92	27.53
Sandy clay	W_1	25.31	22.35	19.15	22.27
	W_2	22.33	21.18	24.65	22.72
	Mean	23.82	21.77	21.90	22.50
Sand	W_1	2.99	4.03	3.15	3.39
	W_2	6.16	4.12	3.95	4.73
	Mean	4.56	4.08	3.55	4.06
		Means of water salinity treatments			
	W_1	17.52	18.66	16.30	17.49
	W_2	17.89	17.19	20.61	18.56
Grand mean		17.71	17.93	18.46	

LSD (0.05):

S=0.70; W=0.57; R=NS; WR=0.99; WS=NS; RS=1.22; WRS=1.72

LSD (0.01):

S=0.94; W=0.77; R=NS; WR=1.33; WS=NS; RS=1.63; WRS=2.31

W_1 = 3.59; W_2 = 7.18 dS/m

*NS = not significant

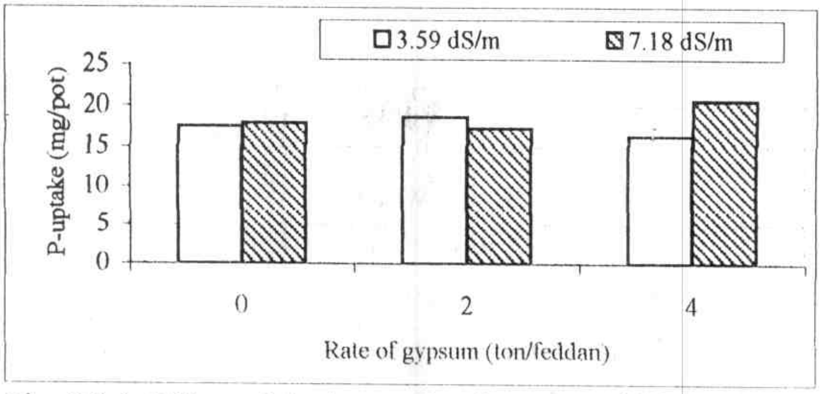

Fig. (20a): Effect of the interaction between addition rates of gypsum and water salinity on P-uptake by total yield

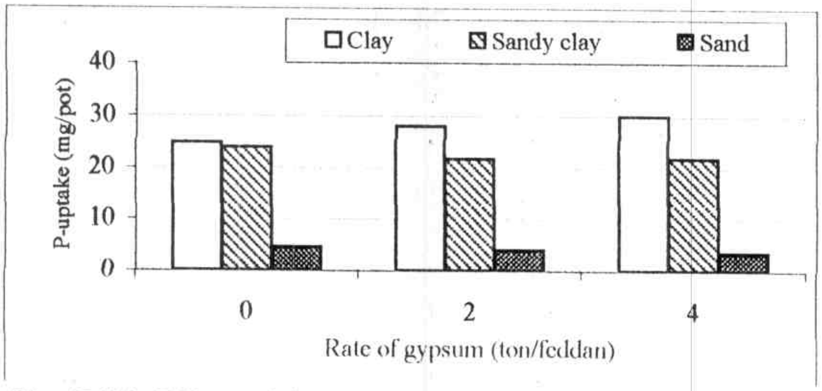

Fig. (20b): Effect of the interaction between addition rates of gypsum and soil type on P-uptake by total yield

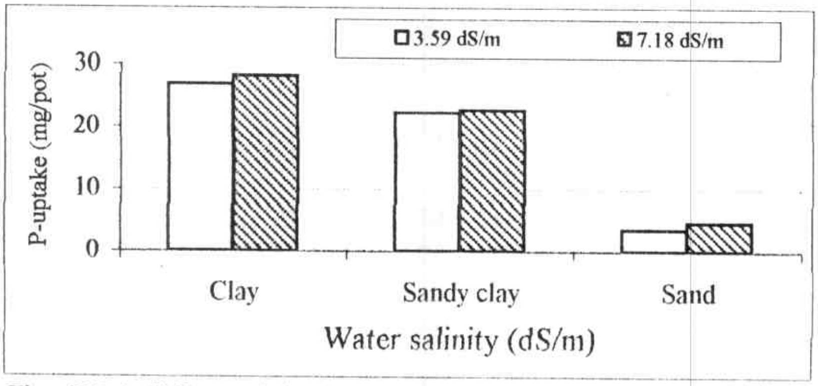

Fig. (20c): Effect of the interaction between water salinity and soil type on P-uptake by total yield its rates. Under conditions of W_2 the only positive significant effect was at the highest rate of gypsum (R_2). In the sandy clay soil and under conditions of W_2, the only positive significant effect was at the highest rate of gypsum application (R_2).

It could be conclude that, the 4 ton gypsum/fed rate under conditions of higher salinity water (7.18 dS/m) may result in giving the highest P-uptake by the plant. This conclusion was confirmed with **Mohamed (1987)** who reported that available P in soil was positively correlated with total soluble salts in the soil solution possibly due to a solubilization of P under the effect of sodium salts especially chlorides and sulphates.

K-uptake by total yield "Table 21 and Fig. 21"

The gypsum addition rate of 2 ton/fed gave the highest average K-uptake by the total yield followed by the gypsum addition rate of 4 ton/fed. The average increase in K-uptake was 9.79 % upon applying R_1. In the clay soil, R_2 showed marked increase of 20.61 %. In the sandy clay and sand soils, no significant response to the gypsum application was found at both gypsum rates. Hence, the positive effect of gypsum application in reducing salinity stress was more effective in the clay soil. In this particular soil, gypsum application under condition of irrigation with the lower salinity water (W_1) was effective at all its rates; but with W_2, the only positive significant effect was at R_1.

In the sandy clay soil, the only positive significant effect was at R_1 addition rate under condition of irrigation with the higher salinity water (W_2). **Abou El-Defan et al. (1999)** applied

Table (21): Effect of gypsum addition under conditions of irrigation with very-high salinity and excessively-high salinity waters on K-uptake (mg/pot) by total yield (grains + straw) applied to wheat grown on light and heavy soils.

Soil [S]	Water salinity [W]	Rate of gypsum (ton/feddan) [R]			
		0	2	4	Mean
Clay	W_1	251.1	355.1	358.7	321.6
	W_2	311.7	323.7	41.2	225.5
	Mean	281.4	339.4	199.9	273.6
Sandy clay	W_1	190.1	161.7	191.6	181.1
	W_2	210.6	229.0	15.1	151.6
	Mean	200.4	195.4	103.4	166.4
Sand	W_1	14.7	31.3	17.6	21.2
	W_2	27.1	3.1	9.8	13.3
	Mean	20.9	17.2	13.7	17.3
		Means of water salinity treatments			
	W_1	152.0	182.7	189.3	174.7
	W_2	183.1	185.3	22.0	130.1
Grand mean		167.6	184.0	105.7	

LSD (0.05):
S=1.46; W=1.19; R=1.46; WR=2.07; WS=2.07; RS=2.54; WRS=3.59

LSD (0.01):
S=1.96; W=1.60; R=1.96; WR=2.78; WS=2.78; RS=3.39; WRS=4.80

W_1 = 3.59; W_2 = 7.18 dS/m

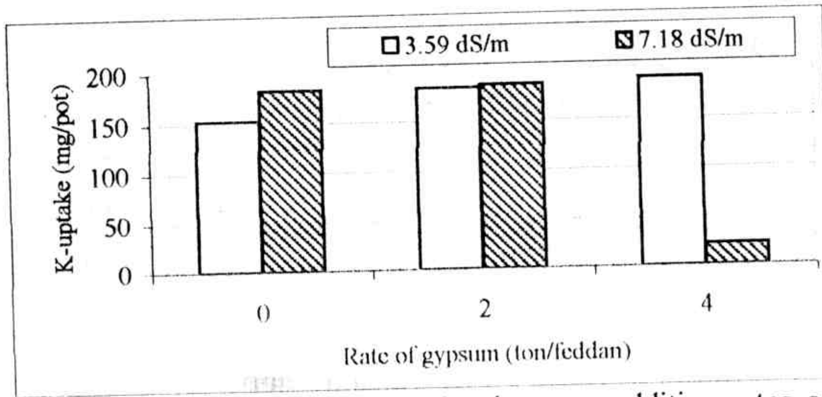

Fig. (21a): Effect of the interaction between addition rates of gypsum and water salinity on K-uptake by total yield.

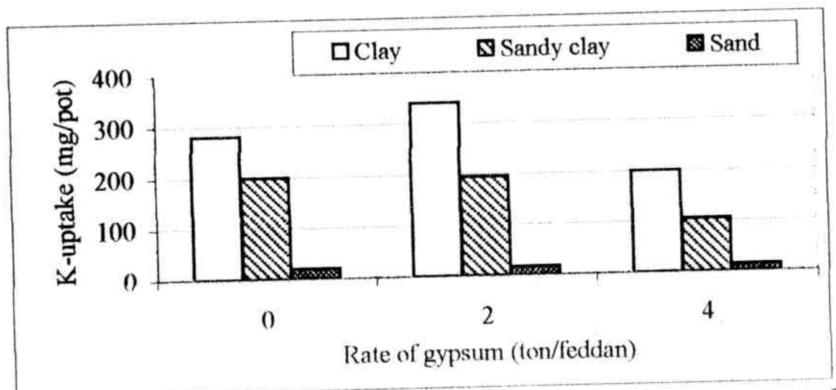

Fig. (21b): Effect of the interaction between addition rates of gypsum and soil type on K-uptake by total yield.

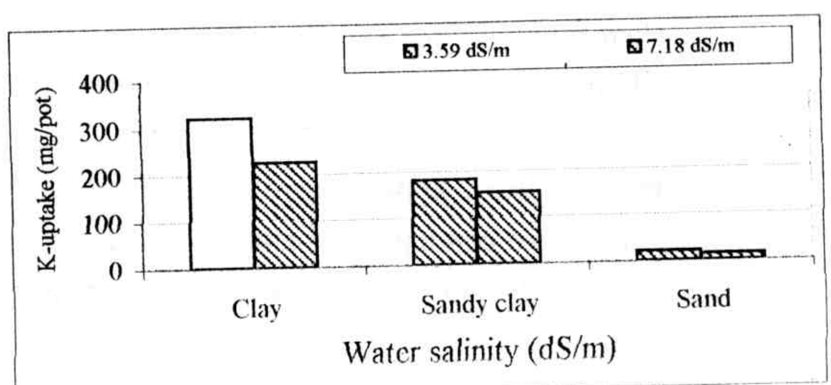

Fig. (21c): Effect of the interaction between water salinity and soil type on K-uptake by total yield.

gypsum up to 4 ton/fed and obtained an increase in contents of available K in soil.

N-uptake by grain yield "Table 22 and Fig. 22"

The main effect shows that application of the highest rate of gypsum did not show a significant effect on average. The only positive response to gypsum application occurred under conditions of irrigation with the lower salinity water (W_1) at the highest gypsum addition rate (R_2). The pattern of response was particularly evident with the clay soil, where R_2 showed a significant increase of 4.60 %. In the sandy clay and the sand soils, there was no significant response to gypsum application at all its rates. Therefore, the positive effect of gypsum application in declining salinity stress was more effective in the clay soil only. In clay soil, application of gypsum under conditions of irrigation with the lower salinity water (W_1) was effective at all its rates. However, with the higher salinity water (W_2), no positive significant effect was obtained at all gypsum addition rates. In the sandy clay soil, the only positive significant effect was at the highest rate of gypsum addition (R_2) under conditions of irrigation with the lower salinity water (W_1).

Therefore, with the gypsum addition rate of 4 ton/fed, the highest N-uptake by grains occurred under conditions of irrigation with the lower salinity water (3.59 dS/m). **Abou El-Defan et al. (1999)**, applied gypsum up to 4 ton/feddan and obtained increased contents of available N, P and K in soil; also, contents of such nutrients in grains increased by gypsum application.

Table (22): Effect of gypsum addition under conditions of irrigation with very-high salinity and excessively-high salinity waters on N-uptake (mg/kg) by grain yield applied to wheat grown on light and heavy soils.

Soil [S]	Water salinity [W]	Rate of gypsum (ton/feddan) [R]			
		0	2	4	Mean
Clay	W_1	482	532	624	546
	W_2	562	459	467	496
	Mean	522	496	546	521
Sandy clay	W_1	431	350	501	427
	W_2	419	296	310	342
	Mean	425	323	406	385
Sand	W_1	47	45	37	43
	W_2	63	51	61	58
	Mean	55	48	49	51
		Means of water salinity treatments			
	W_1	320	249	387	319
	W_2	348	269	279	299
Grand mean		334	259	333	

LSD (0.05):
S=3.67; W=2.99; R=3.67; WR=5.18; WS=5.18; RS=6.35; WRS=8.98

LSD (0.01):
S=7.57; W=6.18; R=7.57; WR=10.7; WS=10.7; RS=13.11; WRS=18.54

W_1 = 3.59; W_2 = 7.18 dS/m

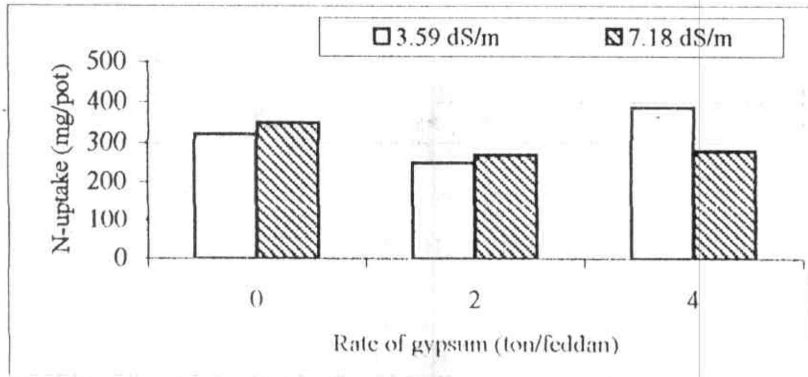

Fig. (22a): *Effect of the interaction between addition rates of gypsum and water salinity on N-uptake by grain yield*

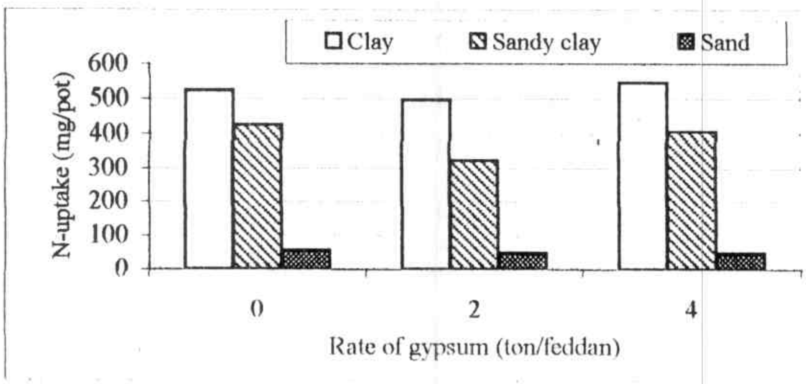

Fig. (22b) Effect of the interaction between addition rates of gypsum and soil type on N-uptake by grain yield

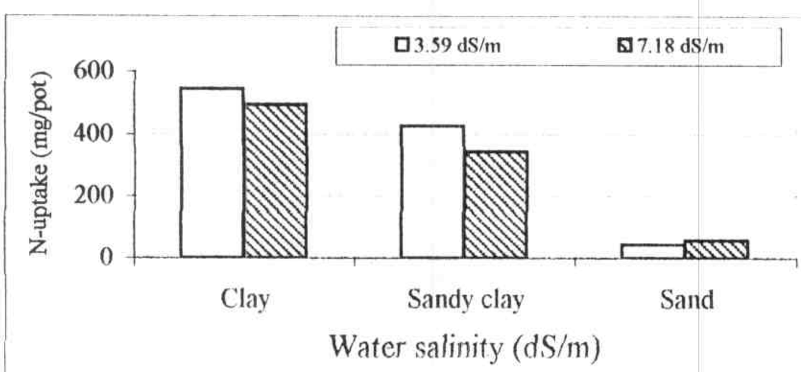

Fig. (22c): Effect of the interaction between water salinity and soil type on N-uptake by grain yield

N-uptake by straw yield "Table 23 and Fig. 23"

The only marked positive response to gypsum application occurred under conditions of irrigation with the lower salinity water (W_1) at the highest gypsum addition rate (R_2). The pattern of response was particularly evident with the clay soil, where R_1 and R_2 showed increases of 1.56 % and 16.80 %, respectively. In the sandy clay and the sand soils, there was no positive response to the gypsum application at all its rates. Thus, the positive effect of gypsum application in alleviating salinity stress was in the clay soil only. In this clay soil, application of gypsum under conditions of irrigation with the lower salinity (W_1) in particular was effective at all its rates. In the sandy clay soil, the only positive significant effect was at the R_1 addition rate under condition of irrigation with the higher salinity water (W_2). In the sand soil, application of gypsum under conditions of irrigation with the lower salinity water (W_1) was effective at all its rates, meanwhile, irrigation with the higher salinity water (W_2), didn't give any positive significant effect at all gypsum addition rates.

P-uptake by grain yield "Table 24 and Fig. 24"

According to results of the main effects, application of gypsum increased P-uptake by grains. The increase was progressive with increasing application of gypsum. The average increases in P-uptake by grain yield were 2.14 % and 7.88 % upon applying R_1 and R_2, respectively. The pattern of response to gypsum application occurred under conditions of irrigation with the lower salinity water (W_1) at R_1 gypsum addition rate, and with the higher salinity water (W_2) at the highest gypsum addition rate (R_2). The pattern of response was particularly

Table (23): Effect of gypsum addition under conditions of irrigation with very-high salinity and excessively-high salinity waters on N-uptake (mg/pot) by straw yield applied to wheat grown on light and heavy soils.

Soil [S]	Water salinity [W]	Rate of gypsum (ton/feddan) [R]			
		0	2	4	Mean
Clay	W_1	190	261	336	262
	W_2	322	259	262	281
	Mean	256	260	299	272
Sandy clay	W_1	257	118	151	175
	W_2	237	245	162	215
	Mean	247	182	157	195
Sand	W_1	20	48	34	34
	W_2	67	41	30	46
	Mean	44	45	32	40
		Means of water salinity treatments			
	W_1	156	142	174	157
	W_2	209	182	151	181
Grand mean		183	162	163	

LSD (0.05):

S=0.74; W=0.60; R=0.74; WR=1.04; WS=1.04; RS=1.27; WRS=1.80

LSD (0.01):

S=1.52; W=1.24; R=1.52; WR=2.15; WS=2.15; RS=2.63; WRS=3.72

W_1 = 3.59; W_2 = 7.18 dS/m

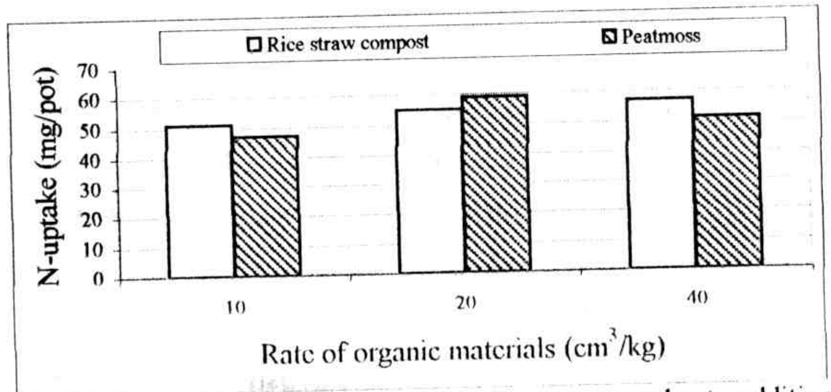

Fig. (38a): Effect of the interaction between type and rate addition of organic material on P-uptake by straw yield

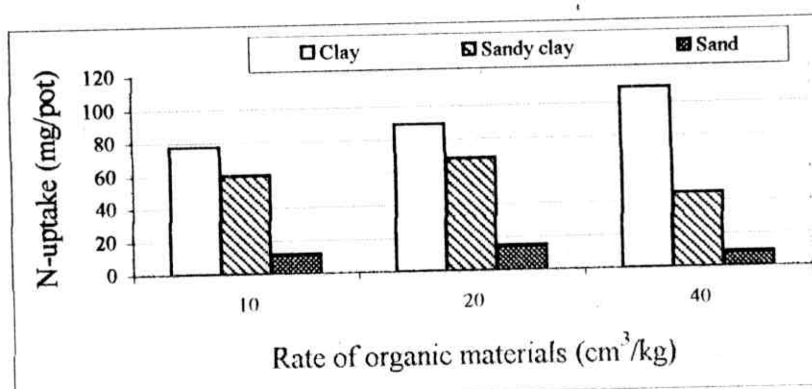

Fig. (38b): Effect of the interaction between addition rates of organic materials and soil type on P-uptake by straw yield

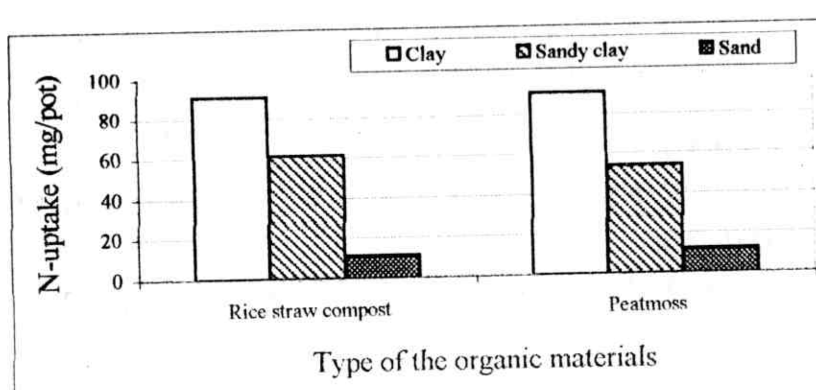

Fig. (38c): Effect of the interaction between the type of organic materials and soil type on P-uptake by straw yield

Table (24): Effect of gypsum addition under conditions of irrigation with very-high salinity and excessively-high salinity waters on P-uptake (mg/pot) by grain yield applied to wheat grown on light and heavy soils.

Soil [S]	Water salinity [W]	Rate of gypsum (ton/feddan) [R]			
		0	2	4	Mean
Clay	W_1	16.55	20.04	18.21	18.27
	W_2	18.53	18.40	21.03	19.32
	Mean	17.54	19.22	19.62	18.79
Sandy clay	W_1	15.84	16.71	15.54	16.03
	W_2	14.95	12.28	16.84	14.69
	Mean	15.40	14.50	16.19	15.36
Sand	W_1	2.04	1.98	0.99	1.67
	W_2	2.11	2.09	2.91	2.37
	Mean	2.08	2.04	1.95	2.02
		Means of water salinity treatments			
	W_1	11.48	12.91	11.58	11.99
	W_2	11.86	10.92	13.59	12.12
Grand mean		11.67	11.92	12.59	

LSD (0.05):

S=0.41; W=NS; R=0.41; WR=0.58; WS=0.58; RS=0.71; WRS=1.00

LSD (0.01):

S=0.84; W=NS; R=0.84; WR=1.19; WS=1.19; RS=1.46; WRS=NS

W_1 = 3.59; W_2 = 7.18 dS/m

NS = not significant

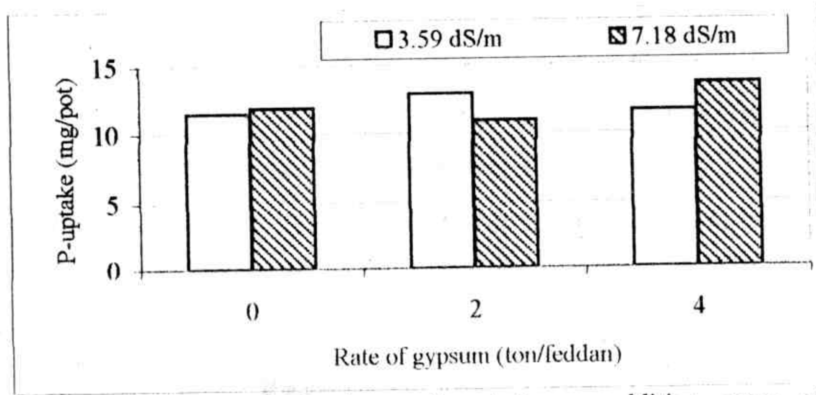

Fig. (24a): Effect of the interaction between addition rates of gypsum and water salinity on P-uptake by grain yield.

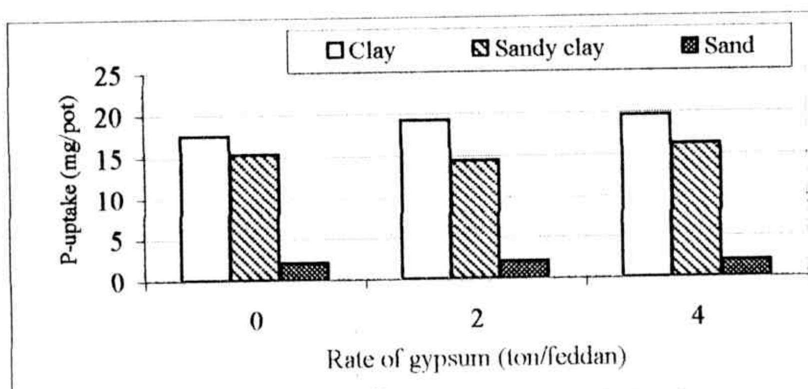

Fig. (24b): Effect of the interaction between addition rates of gypsum and soil type on P-uptake by grain yield.

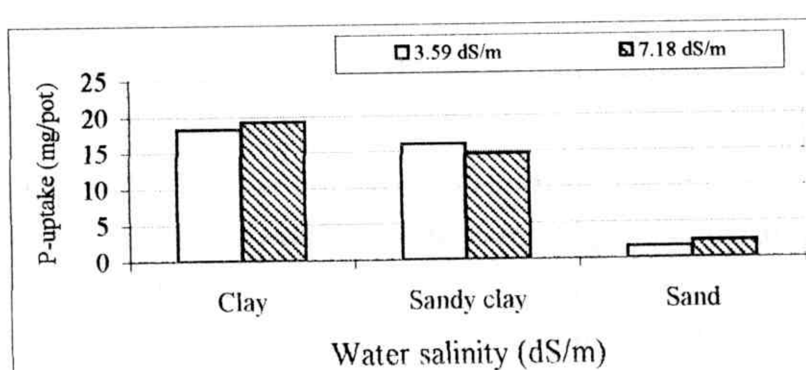

Fig. (24c): Effect of the interaction between water salinity and soil type on P-uptake by grain yield.

evident with the clay soil and the sandy clay soil, where R_1 and R_2 in the clay soil showed marked increases of 9.6 % and 11.9 %, respectively, whereas, in the sandy clay soil, R_2 showed only a marked increase of 5.1 %. In the sand soil, there was no particular pattern of response to gypsum application at all its rates. Therefore, the positive effect of gypsum application in reducing salinity stress was more effective in the heavy soils. Application of gypsum to the sand soil under conditions of irrigation with either water didn't give any significant results at all gypsum addition rates. Therefore, application of gypsum up to 4 ton/fed with to heavy soils under conditions of irrigation with high salinity waters may result in giving a high P-uptake by the plant. **Mohamed (1987)** reported that P in soil was positively correlated with total soluble salts in the soil solution possible due to solubilzation of P under the effect of sodium salts especially chloride and sulphate. The clay soil, application of gypsum under condition of irrigation with lower salinity water (W_1) at R1 and R_2 gave significant response. However, irrigation with higher salinity water (W_2) gave only significant response at the highest gypsum addition rate (R_2). Application of gypsum to the sandy clay soil was effective at the highest rate of gypsum R2 under condition of irrigation with the higher salinity water (W_2).

P-uptake by straw yield "Table 25 and Fig. 25"

Under conditions of irrigation with W_2, the main effect of gypsum application over all soils shows an increase in P-uptake only where W_2 was used. Gypsum application under conditions of irrigation with the higher salinity water (W_2) at the highest rate of gypsum (R_2) caused a significant 16.30 % increase in P-

Table (25): Effect of gypsum addition under conditions of irrigation with very-high salinity and excessively-high salinity waters on P-uptake (mg/pot) by straw yield applied to wheat grown on light and heavy soils.

Soil [S]	Water salinity [W]	Rate of gypsum (ton/feddan) [R]			
		0	2	4	Mean
Clay	W_1	7.71	9.55	8.39	8.55
	W_2	6.68	7.88	12.18	8.91
	Mean	7.20	8.72	10.29	8.73
Sandy clay	W_1	9.44	5.64	3.61	6.23
	W_2	7.38	8.90	7.81	8.03
	Mean	8.41	7.27	5.71	7.13
Sand	W_1	0.96	2.05	2.16	1.72
	W_2	4.02	2.02	1.04	2.36
	Mean	2.49	2.04	1.60	2.04
		Means of water salinity treatments			
	W_1	6.04	5.75	4.72	5.50
	W_2	6.03	6.27	7.01	6.44
Grand mean		6.04	6.01	5.87	

LSD (0.05):

S=0.33; W=0.27; R=NS; WR=0.47; WS=0.47; RS=0.58; WRS=0.82

LSD (0.01):

S=0.69; W=0.56; R=NS; WR=0.97; WS=NS; RS=1.19; WRS=1.69

W_1 = 3.59; W_2 = 7.18 dS/m

NS = not significant

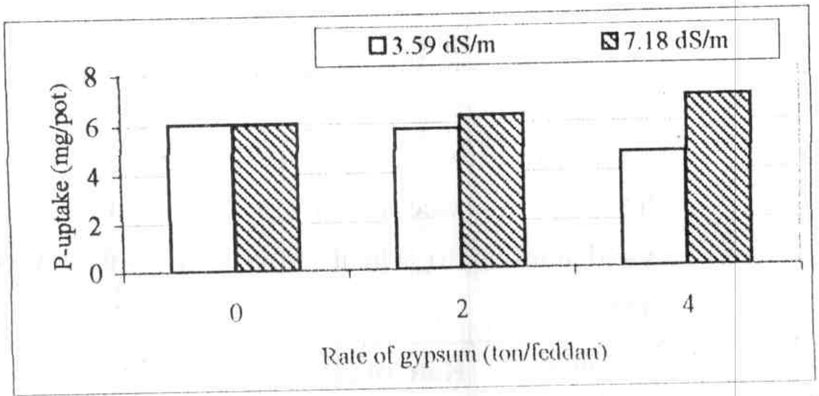

Fig. (25a): Effect of the interaction between addition rates of gypsum and water salinity on P-uptake by straw yield.

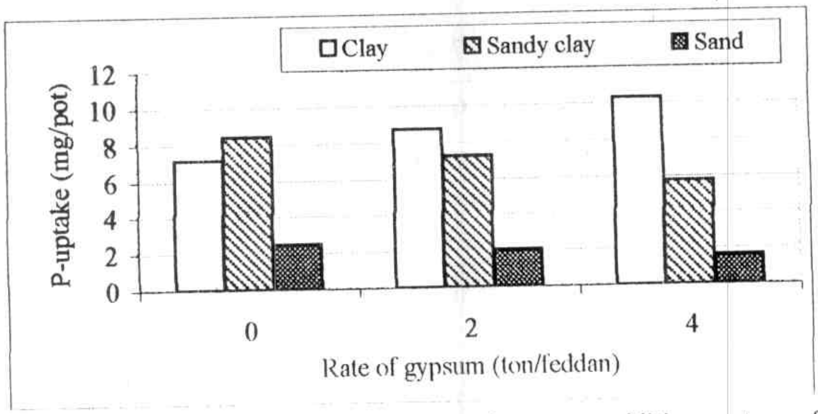

Fig. (25b): Effect of the interaction between addition rates of gypsum and soil type on P-uptake by straw yield.

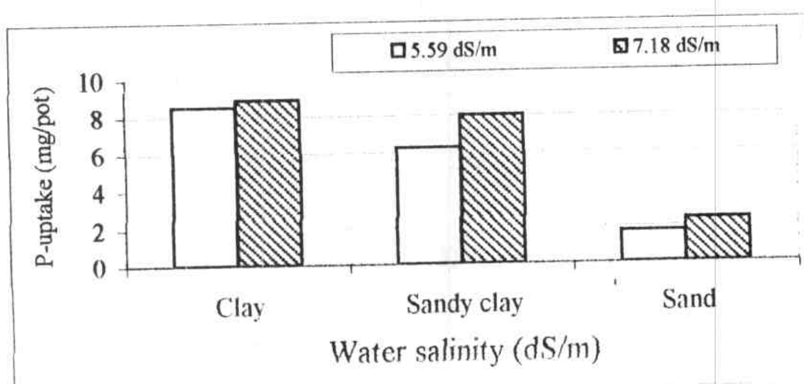

Fig. (25c): Effect of the interaction between water salinity and soil type on P-uptake by straw yield.

uptake. The increase due to gypsum addition was particularly evident with the clay soil. In this particular soil, R_1 and R_2 showed marked increases of 21.11 % and 42.92 %, respectively. In the sandy clay and the sand soils, there was no positive response to the gypsum application at all its rates. Therefore, the positive effect of gypsum application in increasing P-uptake was more effective in clay soil only. Application of gypsum to the clay soil under conditions of irrigation with the lower salinity water (W_1) was effective at R_1 gypsum addition rate only, while, with the higher salinity water (W_2) was effective at all its rates. Application of gypsum to the sandy clay soil under conditions of irrigation with W_1 water was not effective at all its rates, and the only positive significant effect was at R_1 rate under conditions of irrigation with W_2 water. Application of gypsum to the sand soil under conditions of irrigation with W_1 water increased P-uptake in straw at all its rates, whereas, with W_2 water was not effective at all its rates. Therefore, application of gypsum up to 4 ton/fed to the heavy soil under condition of irrigation with high salinity water increased high P-uptake by the plant.

<u>K-uptake by grain yield "Table 26 and Fig. 26"</u>

Application of gypsum increased K-uptake by grains particularly at R_1. The increase was not progressive with increasing application of gypsum. The average increase in K-uptake by grain yield was 8.52 % upon applying R_1. Also, this pattern of response to gypsum application occurred particularly under conditions of irrigation with the lower salinity water (W_1). Response was more evident with the clay soil, where R_1 showed increase of 18.3 %. In the sandy clay and sand soils, the response

Table (26): Effect of gypsum addition under conditions of irrigation with very-high salinity and excessively-high salinity waters on K-uptake (mg/pot) by grain yield applied to wheat grown on light and heavy soils.

Soil [S]	Water salinity [W]	Rate of gypsum (ton/feddan) [R]			
		0	2	4	Mean
Clay	W_1	180.0	240.5	233.5	218.0
	W_2	198.1	206.9	26.1	143.7
	Mean	189.1	223.7	129.8	180.9
Sandy clay	W_1	119.2	120.7	147.4	129.1
	W_2	134.2	125.4	9.9	89.8
	Mean	126.7	123.1	78.7	109.5
Sand	W_1	10.4	15.4	9.4	11.7
	W_2	13.0	2.1	6.7	7.3
	Mean	11.7	8.8	8.1	9.5
		Means of water salinity treatments			
	W_1	103.2	125.5	130.1	119.6
	W_2	115.1	111.5	14.2	80.3
Grand mean		109.2	118.5	72.2	

LSD (0.05):
S=0.91; W=0.75; R=0.91; WR=1.29; WS=1.29; RS=1.58; WRS=2.24
LSD (0.01):
S=1.89; W=1.54; R=1.89; WR=2.67; WS=2.67; RS=3.27; WRS=4.62

W_1 = 3.59; W_2 = 7.18 dS/m

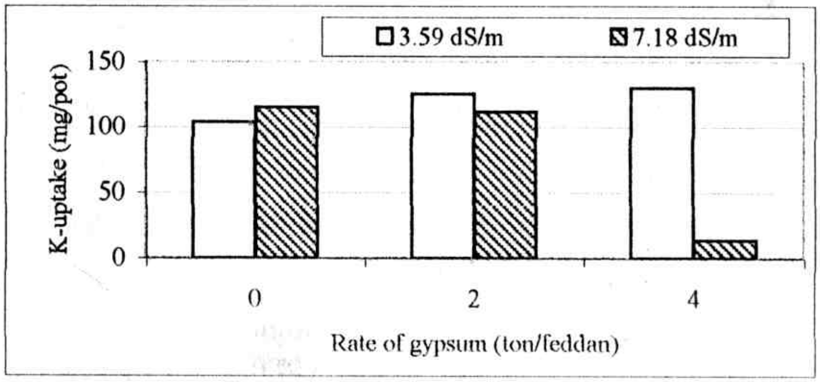

Fig. (26a): Effect of the interaction between addition rates of gypsum and water salinity on K-uptake by grain yield.

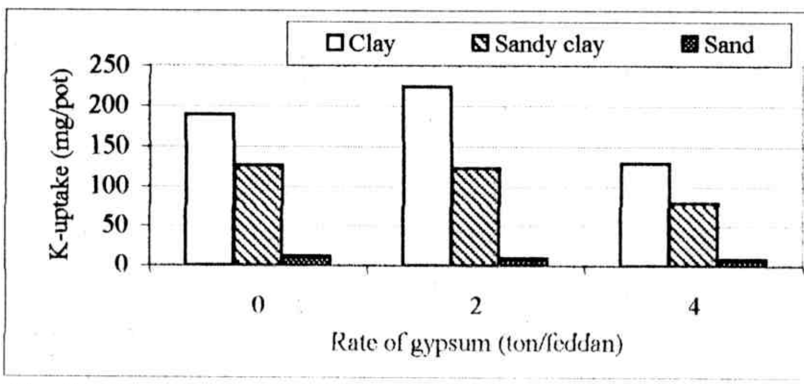

Fig. (26b): Effect of the interaction between addition rates of gypsum and soil type on K-uptake by grain yield.

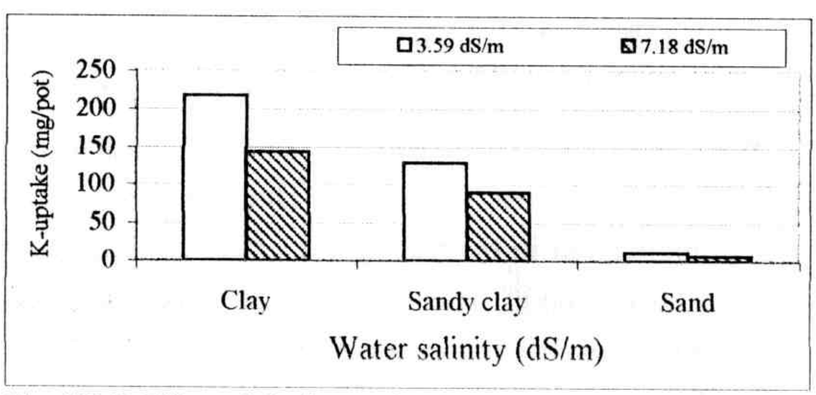

Fig. (26c): Effect of the interaction between water salinity and soil type on K-uptake by grain yield.

was slight. Thus, the positive effect of gypsum application in reducing the effect of salinity stress on K-uptake was more effective in the clay soil. Gypsum applied to the clay soil under conditions of irrigation with the lower salinity water (W_1) was effective at both rates. With the higher salinity water (W_2), gypsum was more effective at R_1. Application of gypsum to the sandy clay soil under conditions of irrigation with the lower salinity water was effective at both rates too. Application of gypsum to the sand soil under conditions of irrigation with the W_1 water was more effective at R_1, but with W_2 water, it was not effective. **Abou El-Defan et al. (1999)** applied gypsum up to 4 ton/fed and obtained increase in contents of available K in soil.

K-uptake by straw yield "Table 27 and Fig. 27"

Application of gypsum increased K-uptake by straw, particularly at R_1. The increase was not progressive with increasing gypsum application. The average increase in K-uptake by straw was 12.0 % upon applying R_1. Also, this pattern of response to gypsum application occurred particularly under conditions of irrigation with higher water salinity (W_2), but, with the lower water salinity (W_1), the increase in K-uptake by straw occurred at R_1 and R_2 and was progressive with increasing gypsum application. Response was more evident with the clay soil, where R_1 showed increase of 25.22 %. In the sandy clay and sand soils, the response was slight. Thus, the positive effect of gypsum application in decreasing the effect of salinity stress on K-uptake was more effective in the clay soil. Gypsum application to the clay soil under conditions of irrigation with the lower salinity water (W_1) was effective at both rates. With the

Table (27): Effect of gypsum addition under conditions of irrigation with very-high salinity and excessively-high salinity waters on K-uptake (mg/pot) by straw yield applied to wheat grown on light and heavy soils.

Soil [S]	Water salinity [W]	Rate of gypsum (ton/feddan) [R]			
		0	2	4	Mean
Clay	W_1	71.1	114.6	125.2	103.6
	W_2	113.6	116.8	15.1	81.8
	Mean	92.4	115.7	70.2	92.7
Sandy clay	W_1	71.0	41.0	44.2	52.1
	W_2	76.4	103.6	5.2	61.7
	Mean	73.7	72.3	24.7	56.9
Sand	W_1	4.4	16.0	8.3	9.6
	W_2	14.1	1.0	3.1	6.1
	Mean	9.3	8.5	5.7	7.8
		Means of water salinity treatments			
	W_1	48.8	57.2	59.2	55.1
	W_2	68.0	73.6	7.8	49.8
Grand mean		58.4	65.4	33.5	

LSD (0.05):

S=0.40; W=0.32; R=0.40; WR=0.56; WS=0.56; RS=0.69; WRS=0.97

LSD (0.01):

S=0.82; W=0.67; R=0.82; WR=1.16; WS=1.16; RS=1.42; WRS=2.01

W_1 = 3.59; W_2 = 7.18 dS/m

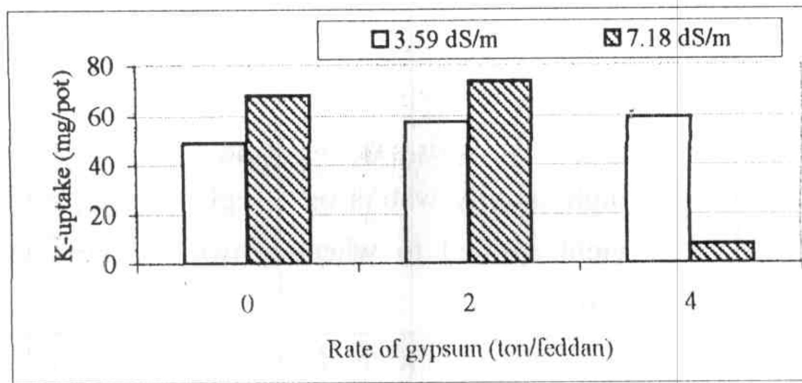

Fig. (27a): Effect of the interaction between addition rates of gypsum and water salinity on K-uptake by straw yield.

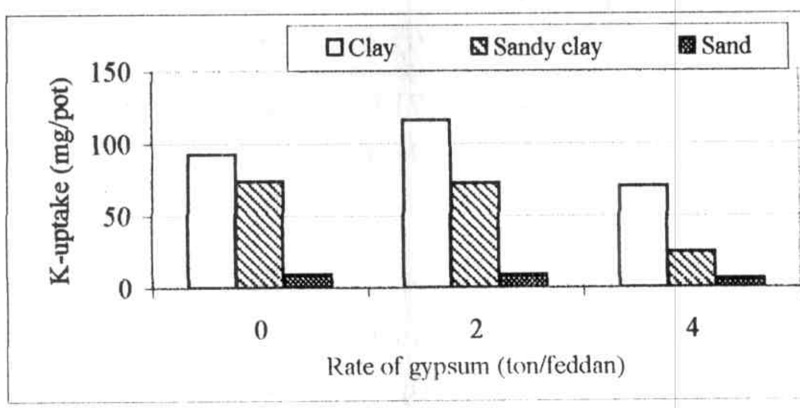

Fig. (27b): Effect of the interaction between addition rates of gypsum and soil type on K-uptake by straw yield.

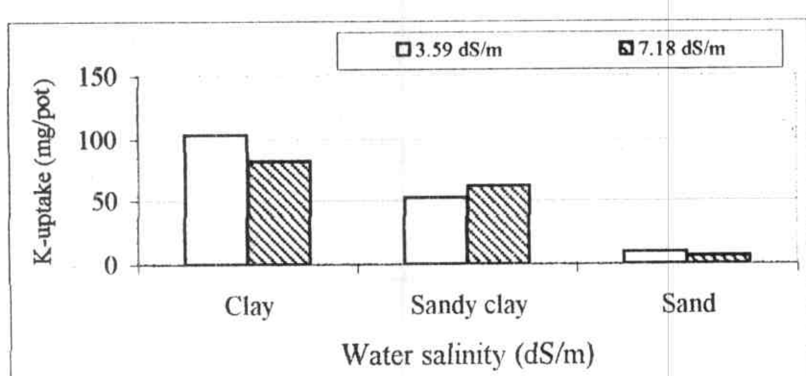

Fig. (27c): Effect of the interaction between water salinity and soil type on K-uptake by straw yield.

higher salinity water (W_2), gypsum was more effective at R_1. Application of gypsum to the sandy clay soil under conditions of irrigation with the higher salinity water was effective only at R_2. Application of gypsum to the sand soil under conditions of irrigation with W_1 water was more effective at both rates, while, with W_2 water, it was not effective. **Abou El-Defan et al. (1999)** applied gypsum up to 4 ton/fed and obtained increase in contents of available K in soil.

<u>EC of soil paste extract "Table 13 of appendix 1 and Fig. 28":</u>

Values of EC were measured at end of experiment. The general trend of salinity before start of experiment and its end shows an increase in salinity (compare table 1 with table 13 of Appendix 1).

EC of soil paste extract increased by addition of gypsum. The average increases in EC were 29.37 and 27.32 % upon applying R_1 and R_2, respectively. This pattern is evident with S_1 and S_2, where R_1 and R_2 which showed marked increases of 16.60 and 16.32 %, respectively in the former and 109.39 and 180.41 %, respectively in the latter. In S_2, however, R_2 showed lower EC than R_0. The trend of response to gypsum application was rather similar in the two water treatments of W_1 and W_2, although with W_2 the salinity magnitude was greater.

<u>Soluble Cl^- of soil paste extract "Table 15 of appendix 1 and Fig. 29":</u>

Values of soluble Cl^- were measured at end of experiment. The general trend of soluble Cl^- before start of

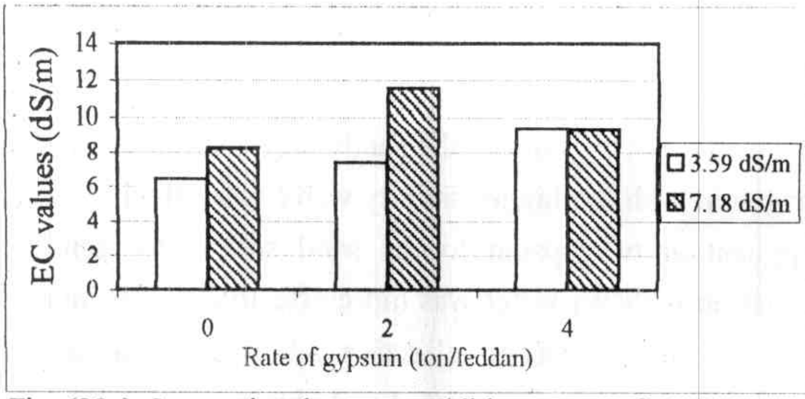

Fig. (28a): *Interaction between addition rates of gypsum and water salinity on EC of soil paste extract.*

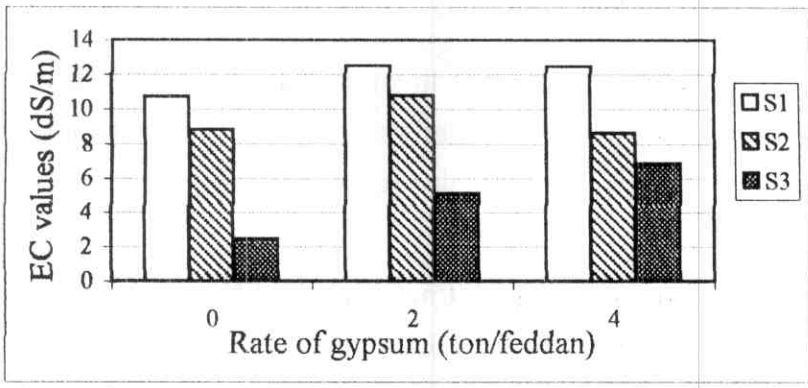

Fig. (28b): Interaction between addition rates of gypsum and soil type on EC of soil paste extract.

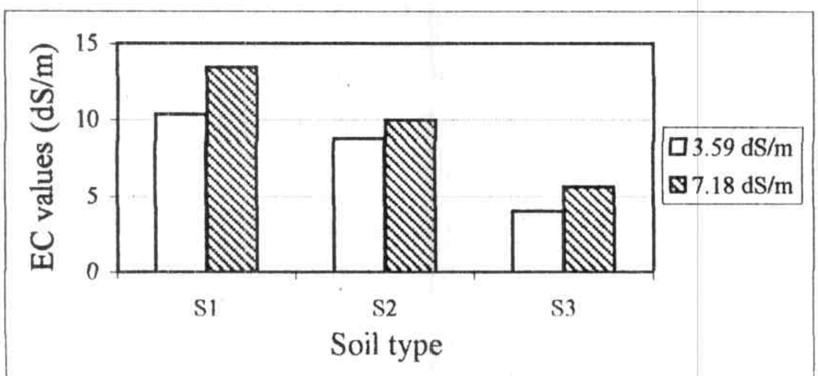

Fig. (28c): Interaction between water salinity and soil type on EC of soil paste extract.

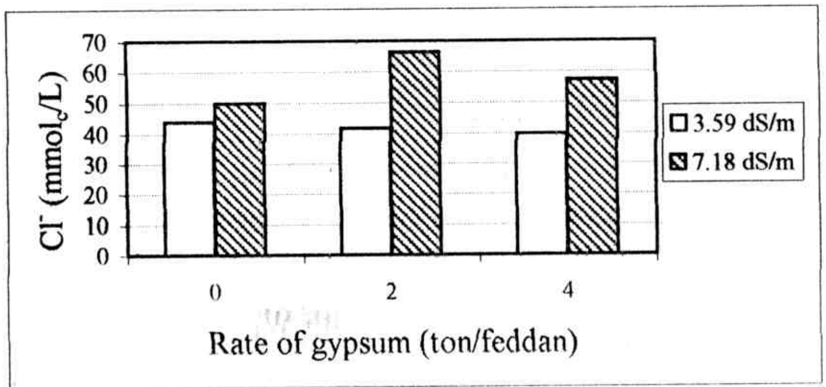

Fig. (29a): Interaction between addition rates of gypsum and water salinity on soluble Cl^- of soil paste extract.

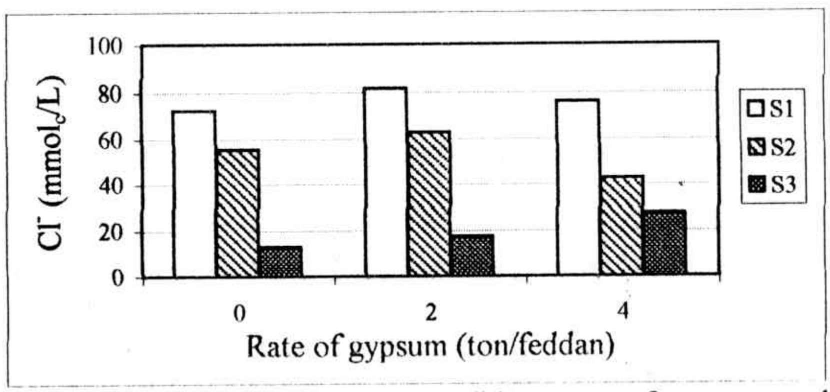

Fig. (29b): Interaction between addition rates of gypsum and soil type on soluble Cl^- of soil paste extract.

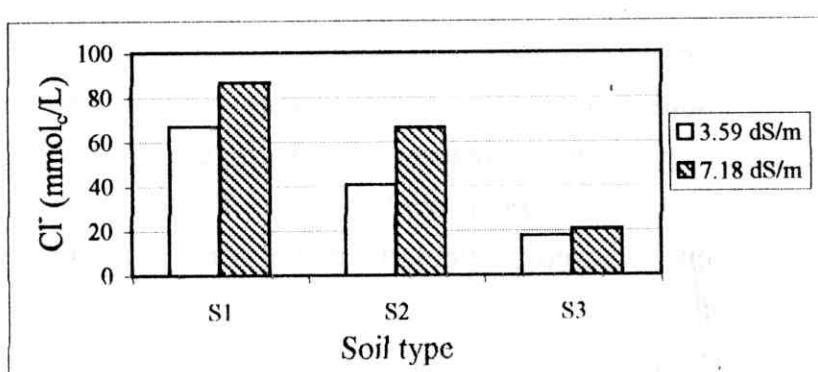

Fig. (29c): Interaction between water salinity and soil type on soluble Cl^- of soil paste extract.

experiment and its end shows a decrease in soluble Cl^- (compare table 1 with table 15 of Appendix 1).

Soluble Cl^- of soil paste extract increased by increasing gypsum addition. The average increases in soluble Cl^- were 15.03 and 3.47 % upon applying R_1 and R_2 gypsum, respectively. This trend occurred with W_1 as well as W_2 although with W_1, the decrease was with the increase in gypsum addition. This pattern was particularly evident with S_1 and S_3, where R_1 and R_2 showed 12.65 and 4.79 % increases, respectively in S_1 and 35.71 and 111.26 %, respectively in S_3. In S_2, R_2 showed 23.3 % decrease. In the clay soil (S_1), the only gypsum addition rate, which was most effective in decreasing the salinity stress, was R_2 under condition of irrigation with lower salinity water (W_1).

Soluble Na^+ of soil paste extract "Table 17 of appendix 1 and Fig. 30":

Values of soluble Na^+ were measured at end of experiment. The general trend of soluble Na^+ before start of experiment and its end shows an increase in soluble Na^+ (compare table 1 with table 17 of Appendix 1).

Application of gypsum increased soluble Na^+, particularly at R_1 addition rate. The increase was not progressive with increasing gypsum application. The average increase in soluble Na^+ was 9.47 % upon applying R_1. Response to gypsum application occurred particularly under conditions of irrigation with the lower salinity water (W_1). Response to gypsum application was more evident with S_2 with 26.62 % decrease at R_2. In S_2, under conditions of irrigation with the lower salinity

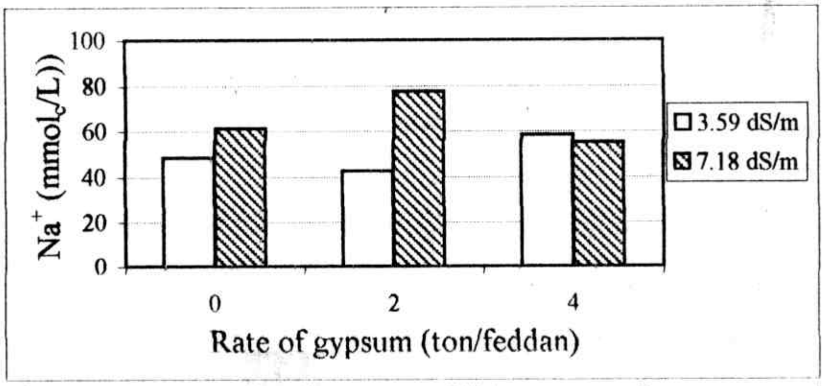

Fig. (30a): *Interaction between addition rates of gypsum and water salinity on soluble soluble* Na^{+} of soil paste

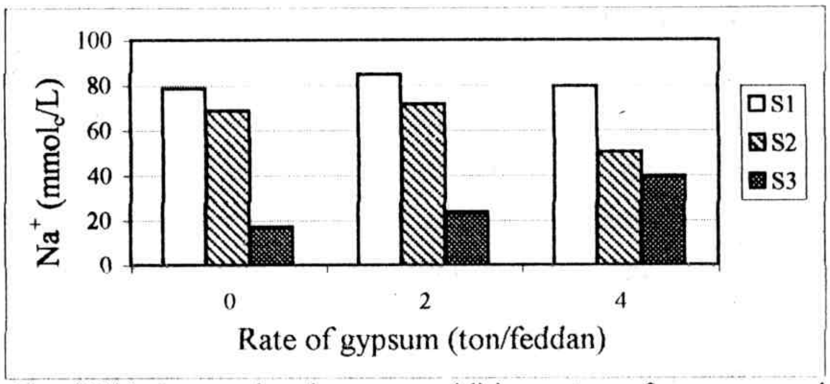

Fig. (30b): Interaction between addition rates of gypsum and soil type on soluble Na^{+} of soil paste extract.

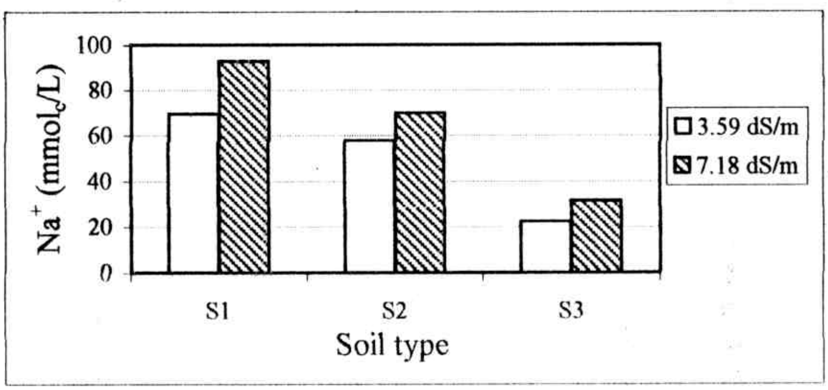

Fig. (30c): Interaction between water salinity and soil type on soluble Na^{+} of soil paste extract.

water (W_1), application of gypsum at both R_1 and R_2 was most effective in decreasing soluble Na^+ with the higher salinity water (W_2). R_2 only decreased soluble Na^+. In S_1 with W_1, R_1 was effective in reducing Na^+, but with W_2, R_2 was effective.

Cônclusive assessment on results of experiment: effect of gypsum addition on alleviating salinity stress.

Application of gypsum, although resulted in increased salinity, it led to increased plant growth. The increased salinity must have been in terms of soluble ions such as Ca^{++} and $SO_4^{=}$. This in turn would render exchanging calcium cations for other cations such as potassium and ammonium on the soil exchange complex. This would lead to increased availability of such macronutrients; therefore increased plant growth and nutrient uptake. Increased contents of soluble sodium and soluble potassium were obtained upon adding gypsum. Improvement in soil physical conditions may have occurred by adding gypsum. Such positive effects of gypsum were more evident in the heavy clay soil.

Experiment 3: organic materials addition:

In this experiment, rice straw compost (M_1) and peatmoss (M_2) were used as amendments of organic matter addition under conditions of irrigation with saline water. They were compared with each other in increasing rates and three soils.

Total yield "Table 28 and Fig. 31":

Straw compost (M_1) gave, on average, wheat total yield (straw + grain) as given by the peatmoss (M_2). For comparisons at each rate, the material "M_1" surpassed "M_2" at R_1 and R_3, giving 5.29 and 1.26 % more yields, respectively. However, increase of M_2 treatment over M_1 occurred at R_2, being 6.5 %. The superiority of M_2 over M_1 in giving greater wheat total yield was most marked in the sand soil giving 11.62 % increase on the average; and such an increase was considerable at R_2 and R_3; at R_2 there was a slight increase of 3.24 %. An increase of M_2 over M_1 was slight in the sandy clay soil (0.74 % increase on average) and an increase of M_1 over M_2 was also slight in the clay soil (1.8 % increase on average). Thus, rice-straw compost was more effective than peatmoss especially at the lowest and the highest addition rates under condition of the clay soil for getting the higher wheat total yield. **Dhawan and Mahajan (1968)** added from 2.5 to 8.3 Mg (megagram "10^6 g" i.e., metric ton) of rice hulls/ha to saline soils as organic amendment and attributed the high yield of wheat to a decrease in soil salinity. Peatmoss however was effective in the sand soil in increasing total yield of wheat particularly most certainly due to increasing soil water retention and improving physical and fertility properties of this coarse textured soil. Increased water-holding pore due to adding

Table (28): Comparative effect of adding rice straw compost or peatmoss to light and heavy soils on total yield (grain + straw) g/pot of wheat irrigated with saline water (3.59 dS/m).

Soil [S]	Organic materials [M]	Rate of organic materials (cm^3/kg soil)			
		10	20	40	Mean
Clay	M_1	35.07	31.27	37.12	34.49
	M_2	32.29	35.09	34.26	33.88
	Mean	33.68	33.18	35.69	34.18
Sandy clay	M_1	19.45	20.30	16.99	18.91
	M_2	19.15	19.76	18.23	19.05
	Mean	19.30	20.03	17.61	18.98
Sand	M_1	4.01	4.25	3.61	3.96
	M_2	4.14	4.62	4.51	4.42
	Mean	4.08	4.44	4.06	4.19
		Means of organic material treatments			
	M_1	19.51	18.61	19.24	19.12
	M_2	18.53	19.82	19.00	19.12
Grand mean		19.02	19.22	19.12	

LSD (0.05):
M=NS; R=0.017; S=0.017; MR=0.023; MS=0.023; RS=0.029; MRS=0.041

LSD (0.01):
M=NS; R=0.022; S=0.022; MR=0.031; MS=0.031; RS=0.039; MRS=0.055

M_1 = rice straw compost; M_2 = peatmoss

*NS = not significant

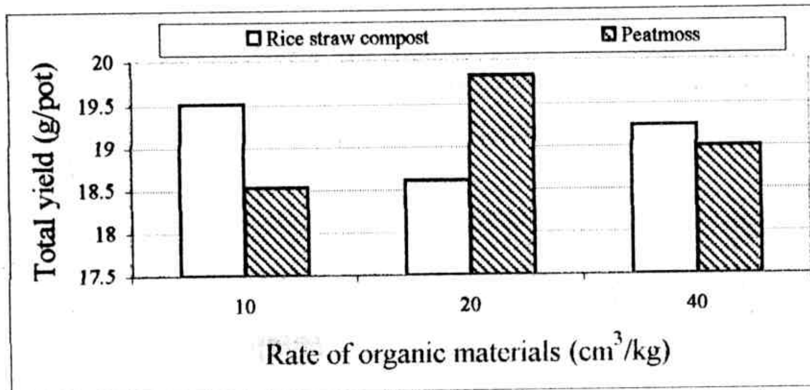

Fig. (31a): Effect of the interaction between type and rate addition of organic material on total yield.

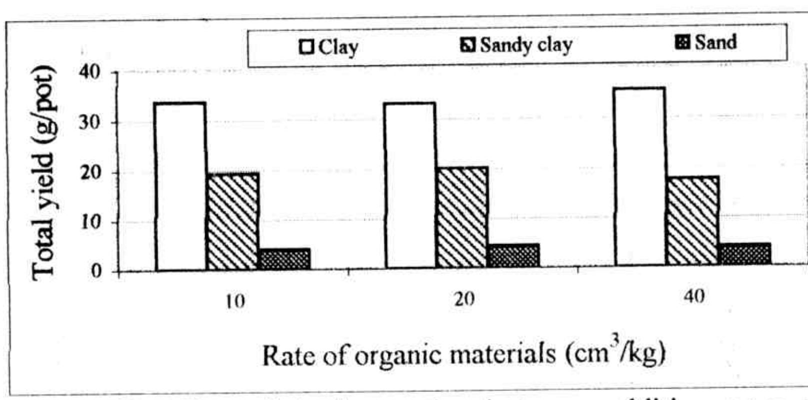

Fig. (31b): Effect of the interaction between addition rates of organic materials and soil type on total yield.

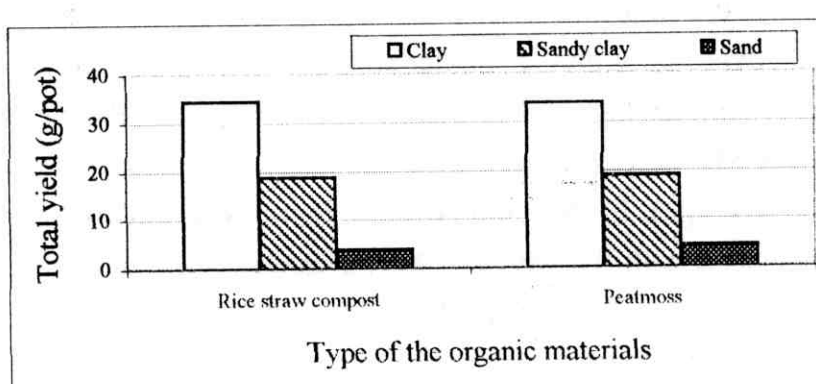

Fig. (31c): Effect of the interaction between the type of organic materials and soil type on total yield peatmoss was reported by **Gouda (1984)** and improving the dynamic soil-water characteristics by decreasing the downward water movement via evaporation was reported by **Ahmed (1981)**.

Grain yield "Table 29 and Fig. 32":

Peatmoss (M_2) gave, in general, 12.0 % greater grain yield over straw compost (M_1). The increases of M_2 over M_1 at R_1, R_2 and R_3 addition rates are 12.11, 14.10 and 9.84 % for R_1, R_2 and R_3, respectively. The superiority of M_2 over M_1 in giving greater grain yield was most marked in the clay soil giving 16.12 % increase on average. The increase of M_2 over M_1 was least marked in the sandy clay soil (5.86 increase on average), the increase was greater at the high rates. In the sand soil, the increase given by M_2 over M_1 occurred with R_2 only. Increasing the soil water retention due to peatmoss effect on water holding is shown in the response of greater grain yield as shown in the response of total yield.

Straw yield "Table 30 and Fig. 33":

Straw compost (M_1) gave an average 11.4 % greater straw yield over peatmoss (M_2). The increases at R_1 and R_3 were rather marked being 22.2 and 13.6 %, respectively. The superiority of M_1 over M_2 in giving greater straw yield was most marked in the clay soil, giving 32.3 % increase on average. The increase of M_1 over M_2 was least marked in the sandy clay soil (3.9 % increase on average). In the sand soil, the increase given by M_1 over M_2 occurred with R_2, whereas, M_2 surpassed M_1 at R_1 and R_3. In the sand soil, superiority of M_1 occurred at R_2 only. The highest

Table (29): Comparative effect of adding rice straw compost or peatmoss to light and heavy soils on grain yield (g/pot) of wheat irrigated with saline water (3.59 dS/m).

Soil [S]	Organic materials [M]	Rate of organic materials (cm^3/kg soil)			
		10	20	40	Mean
Clay	M_1	15.83	16.32	17.36	16.50
	M_2	19.24	18.89	19.34	19.16
	Mean	17.54	17.61	18.35	17.85
Sandy clay	M_1	8.30	8.68	9.13	8.70
	M_2	8.36	9.24	10.03	9.21
	Mean	8.33	8.96	9.58	8.96
Sand	M_1	1.87	1.03	1.85	1.58
	M_2	1.38	1.49	1.77	1.55
	Mean	1.63	1.26	1.81	1.57
		Means of organic material treatments			
	M_1	8.67	8.65	9.45	8.92
	M_2	9.72	9.87	10.38	9.99
Grand mean		9.19	9.26	9.91	

LSD (0.05):

M=0.014; R=0.017; S=0.017; MR=0.023; MS=0.023; RS=0.029; MRS=0.041

LSD (0.01):

M=0.018; R=0.022; S=0.022; MR=0.031; MS=0.031; RS=0.039; MRS=0.055

M_1 = rice straw compost; M_2 = peatmoss

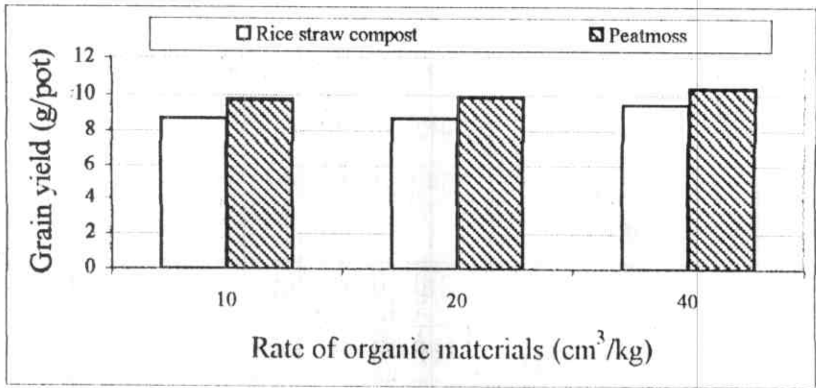

Fig. (32a): Effect of the interaction between type and rate addition of organic material on grain yield

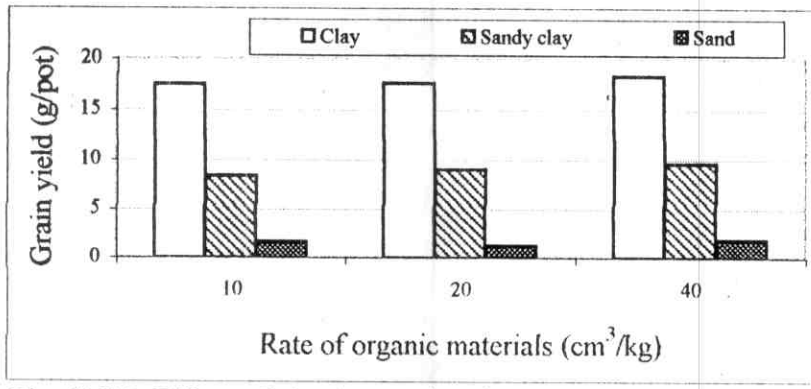

Fig. (32b): Effect of the interaction between addition rates of organic materials and soil type on grain yield

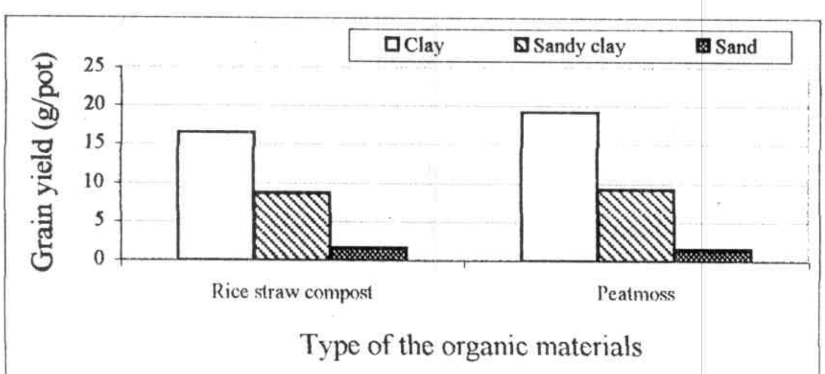

Fig. (32c): Effect of the interaction between the type of organic materials and soil type on grain yield

Table (30): Comparative effect of adding rice straw compost or peatmoss to light and heavy soils on straw yield (g/pot) of wheat irrigated with saline water (3.59 dS/m).

Soil [S]	Organic materials [M]	Rate of organic materials (cm^3/kg soil)			
		10	20	40	Mean
Clay	M_1	19.24	14.95	19.76	19.48
	M_2	13.05	16.20	14.91	14.72
	Mean	16.15	15.58	17.34	16.35
Sandy clay	M_1	11.15	11.62	7.86	10.21
	M_2	10.79	10.51	8.20	9.83
	Mean	10.97	11.07	8.03	10.02
Sand	M_1	2.14	3.22	1.76	2.37
	M_2	2.77	3.13	2.74	2.88
	Mean	2.46	3.18	2.25	2.63
		Means of organic material treatments			
	M_1	10.84	9.93	9.79	10.19
	M_2	8.87	9.95	8.62	9.15
Grand mean		9.86	9.94	9.21	

LSD (0.05):
M=0.010; R=0.012; S=0.012; MR=0.017; MS=0.017; RS=0.020; MRS=0.029

LSD (0.01):
M=0.013; R=0.016; S=0.016; MR=0.022; MS=0.022; RS=0.027; MRS=0.039

M_1 = rice straw compost; M_2 = peatmoss

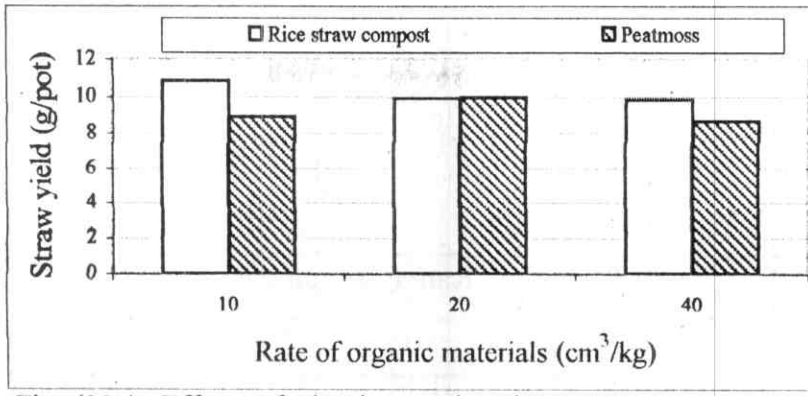

Fig. (33a): Effect of the interaction between type and rate addition of organic material on straw yield

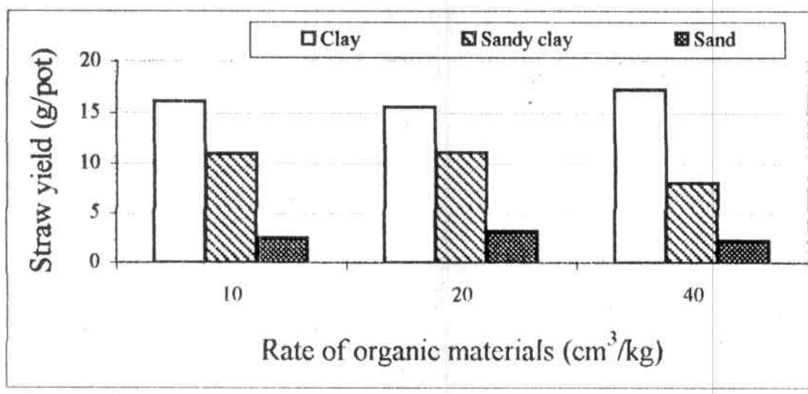

Fig. (33b): Effect of the interaction between addition rates of organic materials and soil type on straw yield

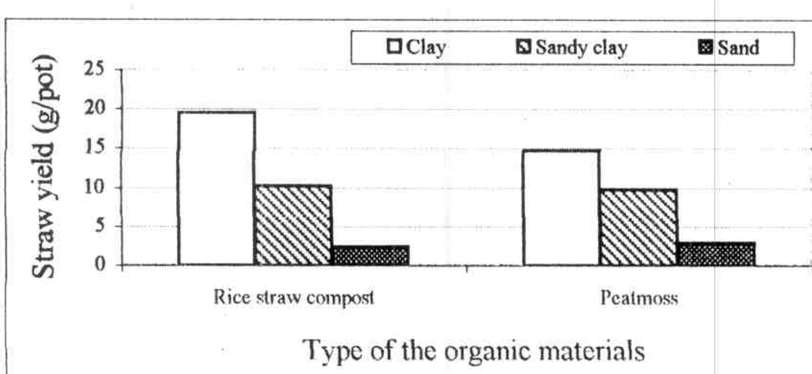

Fig. (33c): Effect of the *interaction between the type of* organic materials and soil type on straw yield straw yield given by the rates of organic material was, in general, that given by R_2 in most cases.

N-uptake by total yield "Table 31 and Fig. 34":

Peatmoss (M_2) gave, in general, 12.58 % greater N-uptake by total yield over straw compost (M_1). At R_1, R_2 and R_3 addition rates increases were 12.69, 19.21 and 5.92 %, respectively. The superiority of M_2 over M_1 in giving greater N-uptake by total yield was most marked in the clay soil giving 25.19 % increase on average. In the sandy clay soil, the increases of M_2 over M_1 occurred at R_1 and R_3. In the sand soil, the increase given by M_2 over M_1 occurred with R_1 and R_2. The highest N-uptake by total yield given by the rates of organic material was in general, that given by R_2 in most cases. Thus, peatmoss has a beneficial effect on N-uptake, as occurred with the yield.

P-uptake by total yield "Table 32 and Fig. 35":

Peatmoss (M_2) gave an average 8.78 % greater P-uptake over straw compost (M_1). At R_1 and R_2 addition rates in particular, the increases were prominent being 10.79 and 13.25 % in the two rates, respectively. The superiority of M_2 over M_1 in giving greater P-uptake by total yield was most marked in the clay soil being 13.35 % increase on average; and such an increase was considerable at R_2 and a slight at R_3. In the sandy clay soil, M_2 and M_1 were rather similar, however, the increase given by M_2 over M_1 was marked at R_1 only. In the sand soil, no significant difference was found between M_2 and M_1. Thus, peatmoss has a beneficial effect on P-uptake, which was associated with the trend in yield.

Table (31): Comparative effect of adding rice straw compost or peatmoss to light and heavy soils on N-uptake (mg/pot) by total yield (grain + straw) of wheat irrigated with saline water (3.59 dS/m).

Soil [S]	Organic materials [M]	Rate of organic materials (cm^3/kg soil)			
		10	20	40	Mean
Clay	M_1	226	227	332	262
	M_2	272	358	355	328
	Mean	249	293	344	295
Sandy clay	M_1	150	202	146	166
	M_2	154	153	163	157
	Mean	152	178	155	161
Sand	M_1	26	25	28	26
	M_2	28	29	18	25
	Mean	27	27	23	26
		Means of organic material treatments			
	M_1	134	151	169	151
	M_2	151	180	179	170
Grand mean		143	166	174	

LSD (0.05):
M=0.51; R=0.62; S=0.62; MR=0.88; MS=0.88; RS=1.08; MRS=1.53
LSD (0.01):
M=68; R=0.84; S=0.84; MR=1.18; MS=1.18; RS=1.45; MRS=2.05

M_1 = rice straw compost; M_2 = peatmoss

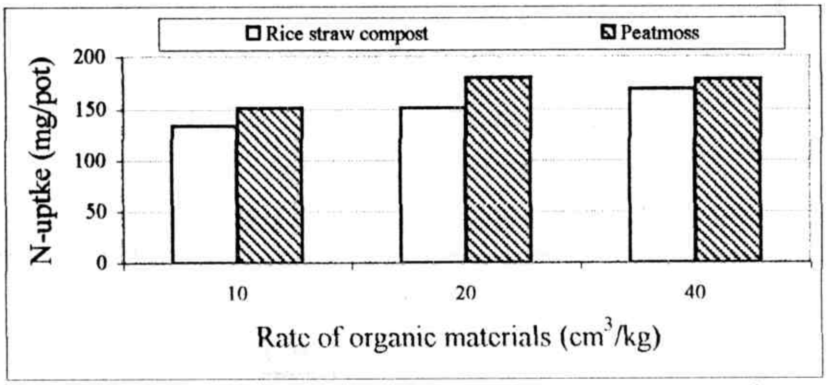

Fig. (34a): *Effect of the interaction between type and rate* addition of organic material on N-uptake by total yield

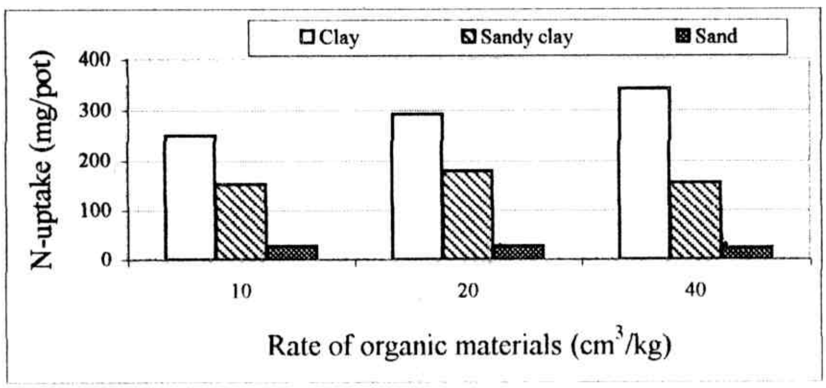

Fig. (34b): Effect of the interaction between addition rates of organic materials and soil type on N-uptake by total yield

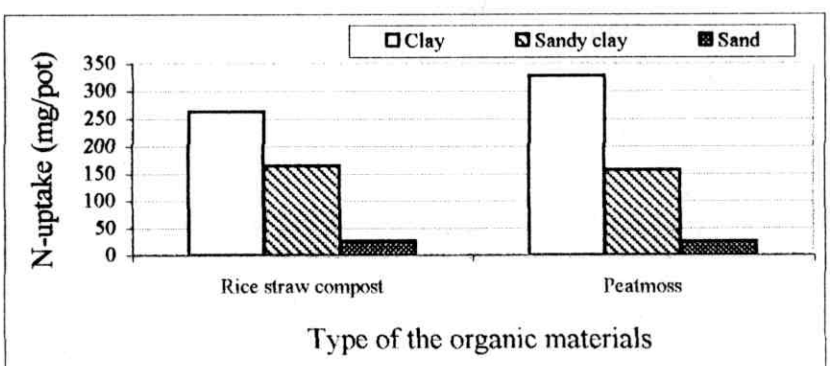

Fig. (34c): Effect *of the interaction between the type of* organic materials and soil type on N-uptake by

Table (32): Comparative effect of adding rice straw compost or peatmoss to light and heavy soils on P-uptake (mg/pot) by total yield (grain + straw) of wheat irrigated with saline water (3.59 dS/m).

Soil [S]	Organic materials [M]	Rate of organic materials (cm^3/kg soil)			
		10	20	40	Mean
Clay	M_1	18.03	16.45	21.72	18.73
	M_2	17.62	22.85	23.23	21.23
	Mean	17.83	19.65	22.48	19.98
Sandy clay	M_1	9.99	13.72	12.41	12.04
	M_2	13.59	11.60	11.97	12.39
	Mean	11.79	12.66	12.19	12.21
Sand	M_1	2.01	2.00	2.04	2.02
	M_2	2.07	1.98	2.16	2.07
	Mean	2.04	1.99	2.10	2.04
		Means of organic material treatments			
	M_1	10.01	10.72	12.06	10.93
	M_2	11.09	12.14	12.45	11.89
Grand mean		10.55	11.43	11.26	
LSD (0.05): M=0.62; R=0.76; S=0.76; MR=NS; MS=1.07; RS=1.32; MRS=1.86					
LSD (0.01): M=0.83; R=1.02; S=1.02; MR=NS; MS=1.44; RS=1.76; MRS=2.50					

M_1 = rice straw compost; M_2 = peatmoss

*NS = not significant

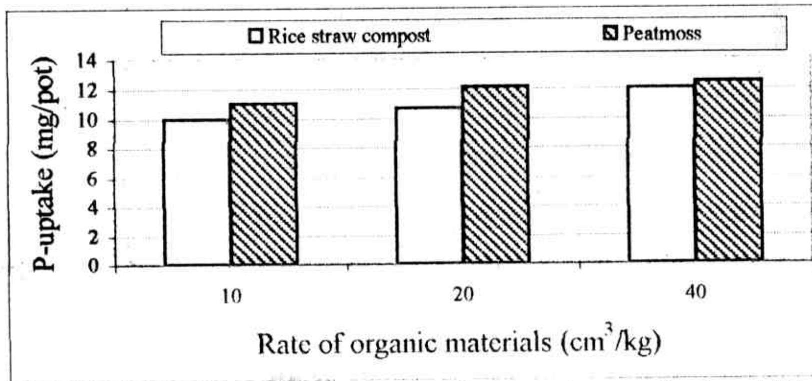

Fig. (35a): Effect of the interaction between type and rate addition of organic material on P-uptake by total yield.

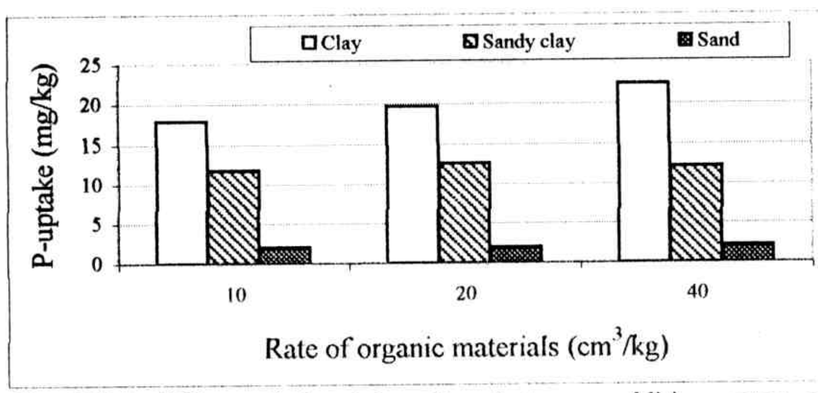

Fig. (35b): Effect of the interaction between addition rates of organic materials and soil type on P-uptake by total yield.

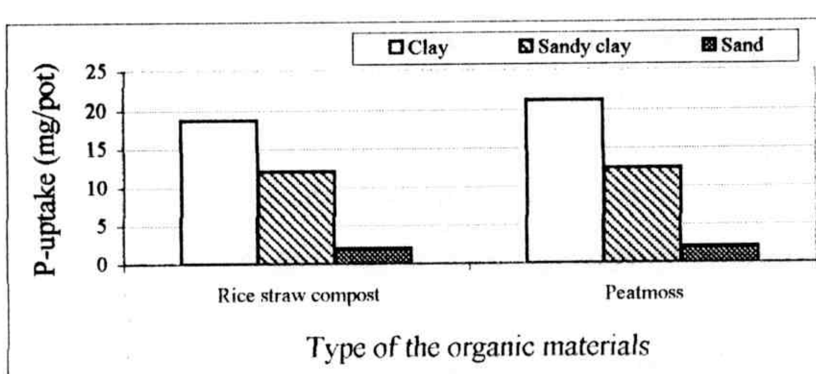

Fig. (35c): Effect of the interaction between the type of organic materials and soil type on P-uptake by total yield.

K-uptake by total yield "Table 33 and Fig. 36":

Peatmoss (M_2) gave on average 9.73 % greater K-uptake over straw compost (M_1). Such increase of M_2 treatment over M_1 occurred at R_1 and R_2 in particular, being 7.76 and 30.04 % in the two rates, respectively. In the clay soil, superiority of M_2 over M_1 was particularly at R_1 and R_2. In the other two soils, it was marked at the 3 rates. In the sandy clay soil, M_2 gave 34.48 % greater than M_1 on average. The greater K-uptake by M_2 over M_1 in this soil was considerable at R_2 and R_3. In the sand soil, M_2 gave 23.01 % greater K-uptake over M_1; and the increase was considerable at R_2 and R_3. In the clay soil, the average increase of M_2 over M_1 was 3.39 %. The highest K-uptake by total yield was given by R_3 in most cases. Thus, peatmoss increased K-uptake, over straw compost.

N-uptake by grains "Table 34 and Fig. 37":

Peatmoss (M_2) gave on average 21.65 greater N-uptake by grain yield over straw compost (M_1). The increases at R_1, R_2 and R_3 are 25.30, 26.04 and 14.29 %, respectively. The superiority of M_2 over M_1 in giving greater N-uptake by grain yield was most marked in the clay soil being 38.60 %. In the sandy clay soil, the increase of M_2 over M_1 occurred at R_1 and R_3 in particular. In the sand soil, the increase given by M_2 over M_1 occurred with R_2 in particular. The highest N-uptake by grain yield over all soils and organic materials was given by R_3.

N-uptake by straw "Table 35 and Fig. 38":

Slight difference occurred between M_1 and M_2 in general. In some cases, M_2 surpassed M_1 and in others the reverse

Table (33): Comparative effect of adding rice straw compost or peatmoss to light and heavy soils on K-uptake (mg/pot) by total yield (grain + straw) of wheat irrigated with saline water (3.59 dS/m).

Soil [S]	Organic materials [M]	Rate of organic materials (cm^3/kg soil)			
		10	20	40	Mean
Clay	M_1	115.5	96.2	150.7	120.8
	M_2	128.4	122.4	123.9	124.9
	Mean	122.0	109.3	137.3	123.9
Sandy clay	M_1	59.7	44.8	42.8	49.1
	M_2	61.4	59.2	60.6	60.4
	Mean	60.6	52.0	51.7	54.8
Sand	M_1	6.5	4.9	6.0	5.8
	M_2	6.1	8.1	9.1	7.8
	Mean	6.3	6.5	7.6	6.8
		Means of organic material treatments			
	M_1	60.6	48.6	66.5	58.6
	M_2	65.3	63.2	64.5	64.3
Grand mean		63.0	55.9	65.5	

LSD (0.05):
M=1.19; R=1.46; S=1.46; MR=2.06; MS=2.06; RS=2.53; MRS=3.57

LSD (0.01):
M=1.60; R=1.96; S=1.96; MR=2.77; MS=2.77; RS=3.39; MRS=4.79

M_1 = rice straw compost; M_2 = peatmoss

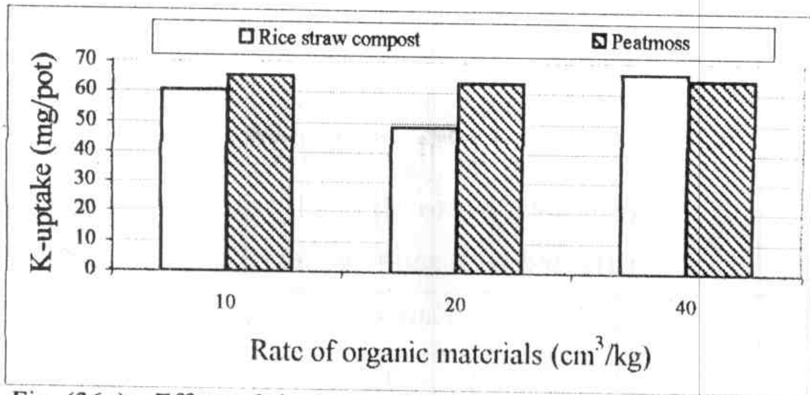

Fig. (36a): *Effect of the interaction between type and rate addition of organic material on K-uptake by total yield.*

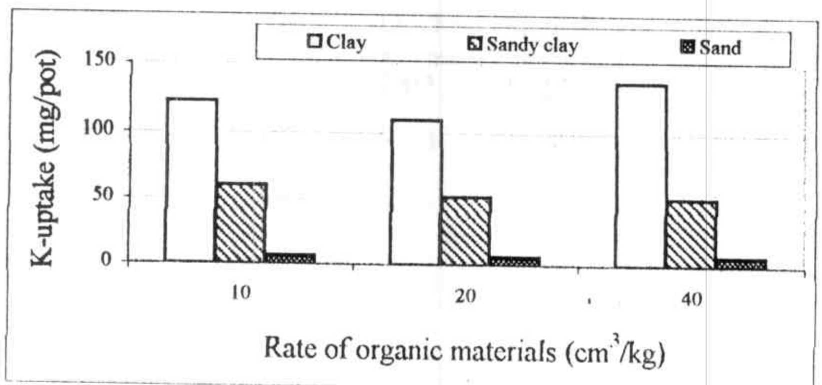

Fig. (36b): Effect of the interaction between addition rates of organic materials and soil type on K-uptake by total yield.

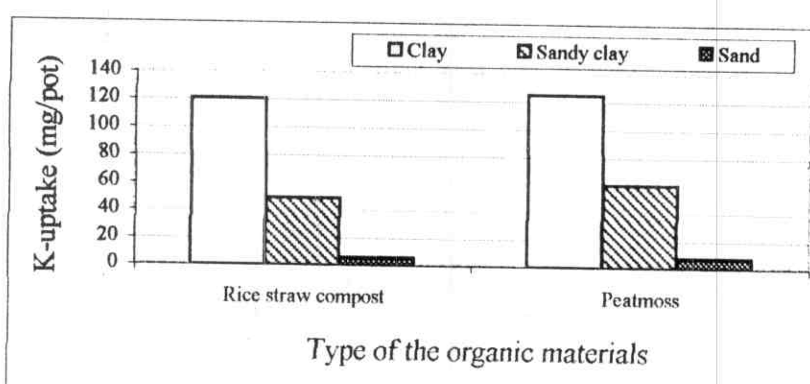

Fig. (36c): Effect of the interaction between the type of organic materials and soil type on K-uptake by total yield.

Table (34): Comparative effect of adding rice straw compost or peatmoss to light and heavy soils on N-uptake (mg/pot) by grain yield of wheat irrigated with saline water (3.59 dS/m).

Soil [S]	Organic materials [M]	Rate of organic materials (cm^3/kg soil)			
		10	20	40	Mean
Clay	M_1	141	157	214	171
	M_2	204	251	257	237
	Mean	173	204	236	204
Sandy clay	M_1	90	122	103	105
	M_2	95	98	116	103
	Mean	93	110	110	104
Sand	M_1	17	10	19	15
	M_2	14	14	10	13
	Mean	16	12	15	14
		Means of organic material treatments			
	M_1	83	96	112	97
	M_2	104	121	128	118
Grand mean		94	109	120	

LSD (0.05):
M=0.19; R=0.23; S=0.23; MR=0.32; MS=0.32; RS=0.39; MRS=0.55
LSD (0.01):
M=0.38; R=0.47; S=0.47; MR=0.66; MS=0.66; RS=0.81; MRS=1.14

M_1 = rice straw compost; M_2 = peatmoss

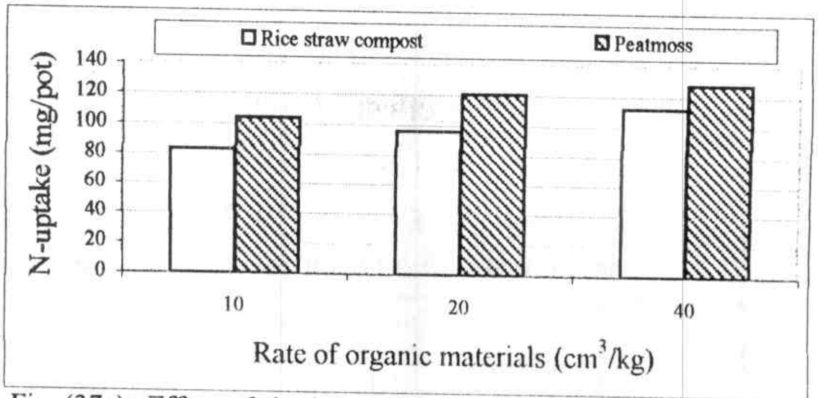

Fig. (37a): *Effect of the interaction between type and rate addition* of organic material on N-uptake by grain yield

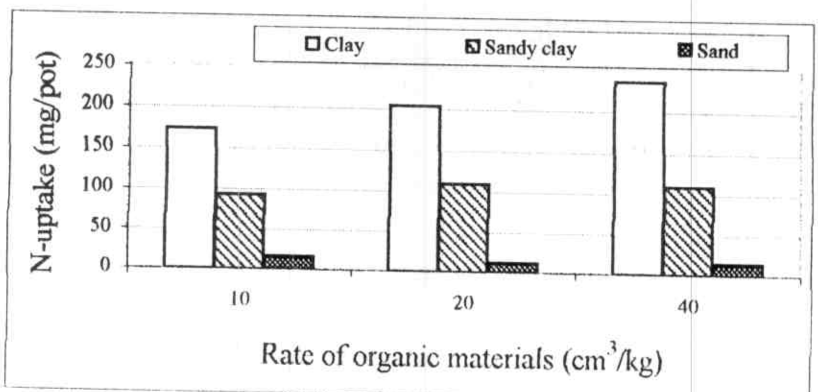

Fig. (37b): Effect of the interaction between addition rates of organic materials and soil type on N-uptake by grain yield

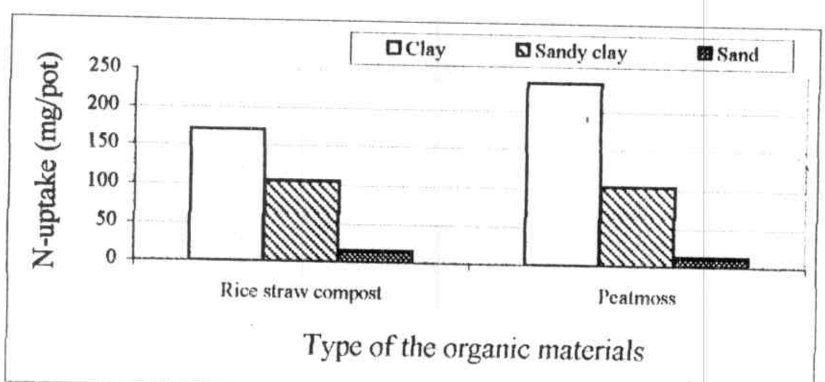

Fig. (37c): Effect of the interaction between the type of organic materials and soil type on N-uptake by grain yield

Table (35): Comparative effect of adding rice straw compost or peatmoss to light and heavy soils on N-uptake (mg/pot) by straw yield of wheat irrigated with saline water (3.59 dS/m).

Soil [S]	Organic materials [M]	Rate of organic materials (cm^3/kg soil)			
		10	20	40	Mean
Clay	M_1	85	70	119	91
	M_2	68	107	98	91
	Mean	77	89	109	91
Sandy clay	M_1	60	80	43	61
	M_2	59	55	47	54
	Mean	60	68	45	57
Sand	M_1	9	15	9	11
	M_2	14	15	8	12
	Mean	12	15	9	12
		Means of organic material treatments			
	M_1	51	55	57	54
	M_2	47	59	51	52
Grand mean		49	57	54	

LSD (0.05):
M=0.11; R=0.13; S=0.13; MR=0.19; MS=0.19; RS=0.23; MRS=0.32

LSD (0.01):
M=0.22; R=0.27; S=0.27; MR=0.38; MS=0.38; RS=0.47; MRS=0.66

M_1 = rice straw compost; M_2 = peatmoss

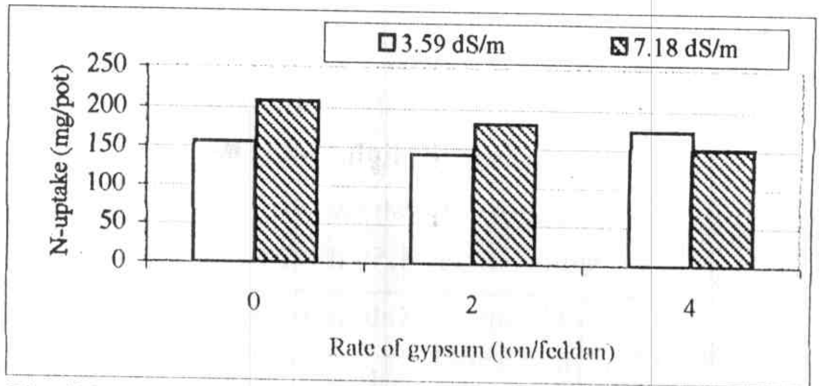

Fig. (23a): *Effect of the interaction between addition rates of* gypsum and water salinity on N-uptake by straw yield

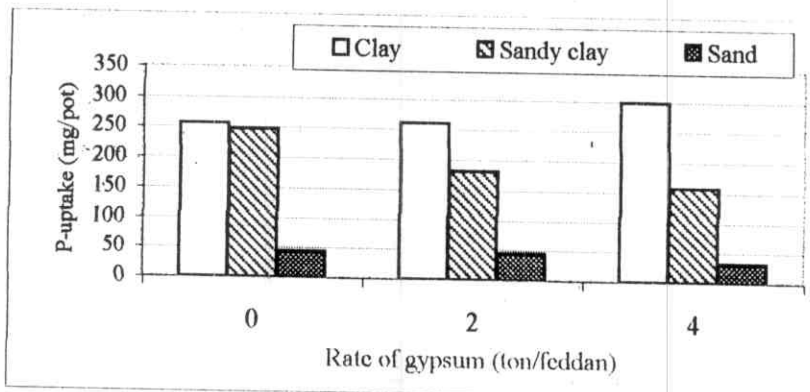

Fig. (23b): Effect of the interaction between addition rates of gypsum and soil type on N-uptake by straw yield

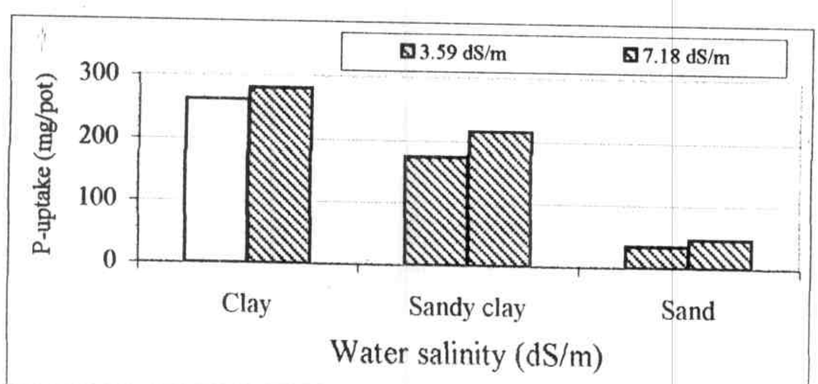

Fig. (23c): Effect of the interaction between water salinity and soil type on P-uptake by straw yield

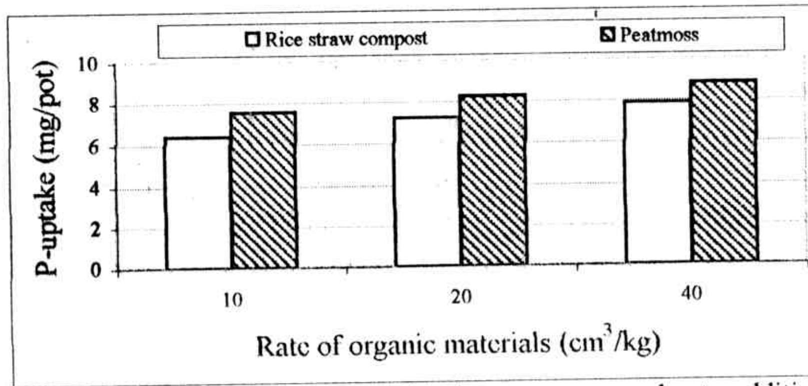

Fig. (39a): Effect of the interaction between type and rate addition of organic material on P-uptake by grain yield.

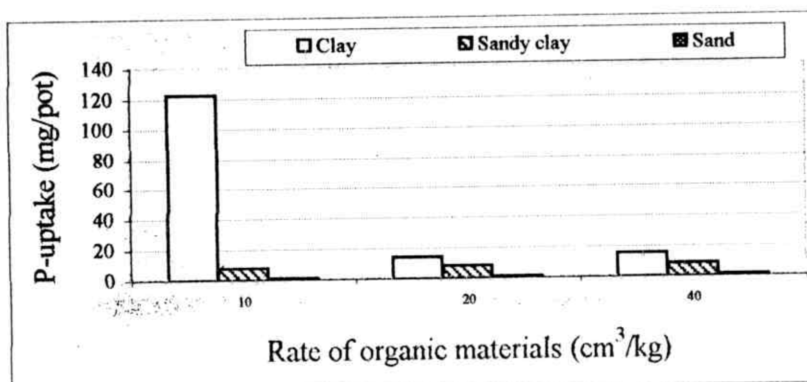

Fig. (39b): Effect of the interaction between addition rates of organic materials and soil type on P-uptake by grain yield.

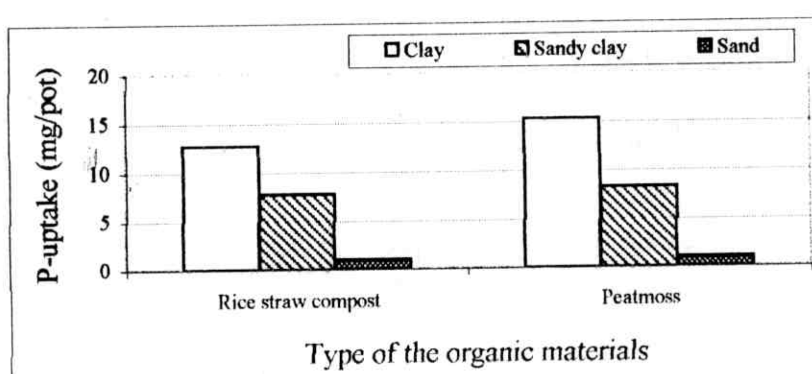

Fig. (39c): Effect of the interaction between the type of organic materials and soil type on P-uptake by grain yield.

Table (37): Comparative effect of adding rice straw compost or peatmoss to light and heavy soils on P-uptake (mg/pot) by straw yield of wheat irrigated with saline water (3.59 dS/m).

Soil [S]	Organic materials [M]	Rate of organic materials (cm^3/kg soil)			
		10	20	40	Mean
Clay	M_1	6.41	4.49	7.25	6.05
	M_2	4.79	6.48	6.46	5.91
	Mean	5.60	5.49	6.86	5.98
Sandy clay	M_1	3.35	5.03	4.20	4.19
	M_2	4.68	4.20	3.28	4.05
	Mean	4.02	4.62	3.74	4.12
Sand	M_1	1.07	0.97	1.05	1.03
	M_2	1.11	0.94	1.10	1.05
	Mean	1.09	0.96	1.08	1.04
		Means of organic material treatments			
	M_1	3.61	3.50	4.17	3.76
	M_2	3.53	3.87	3.61	3.67
Grand mean		3.57	3.69	3.89	

LSD (0.05):

M=NS; R=NS; S=0.29; MR=NS; MS=NS; RS=0.50; MRS=0.71

LSD (0.01):

M=NS; R=NS; S=0.60; MR=NS; MS=NS; RS=1.04; MRS=1.47

M_1 = rice straw compost; M_2 = peatmoss

*NS = not significant

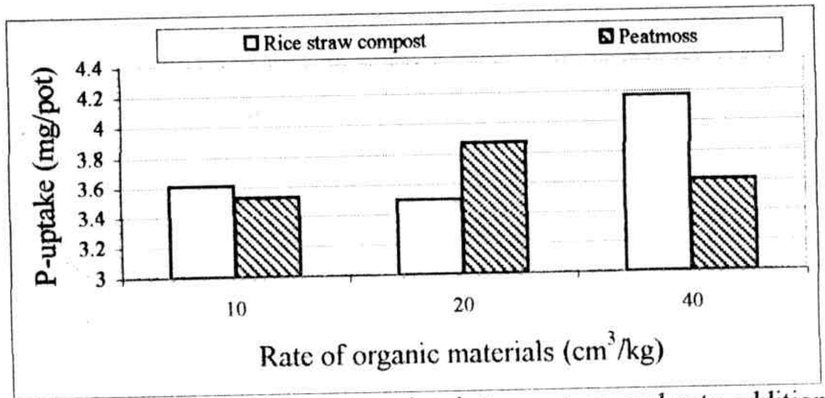

Fig. (40a): Effect of the interaction between type and rate addition of organic material on P-uptake by straw yield.

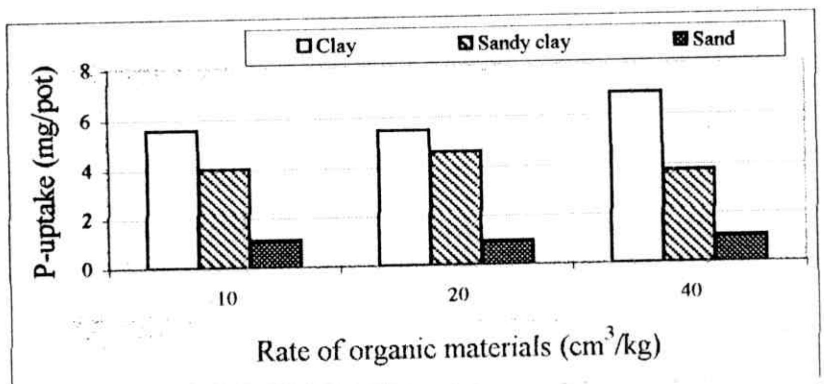

Fig. (40b): Effect of the interaction between addition rates of organic materials and soil type on P-uptake by straw yield.

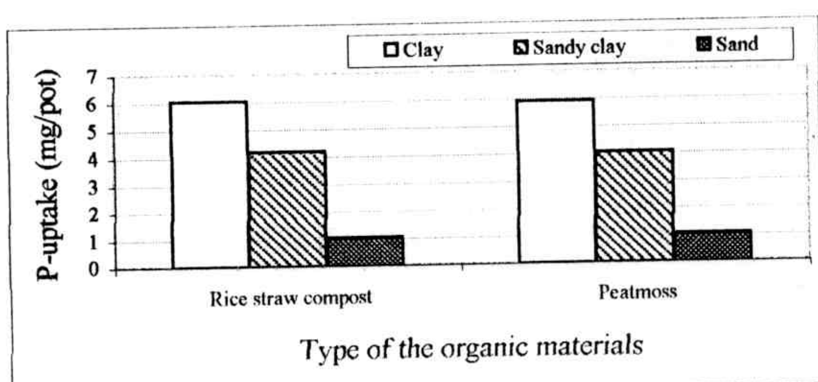

Fig. (40c): Effect of the interaction between the type of organic materials and soil type on P-uptake by straw yield.

Table (38): Comparative effect of adding rice straw compost or peatmoss to light and heavy soils on K-uptake (mg/pot) by grain yield of wheat irrigated with saline water (3.59 dS/m).

Soil [S]	Organic materials [M]	Rate of organic materials (cm^3/kg soil)			
		10	20	40	Mean
Clay	M_1	77.6	65.3	96.7	79.9
	M_2	94.9	86.3	89.6	90.3
	Mean	86.3	75.8	93.2	85.1
Sandy clay	M_1	37.4	26.6	28.9	31.0
	M_2	38.2	38.5	43.1	39.9
	Mean	37.8	32.6	36.0	35.5
Sand	M_1	4.6	2.0	4.0	3.5
	M_2	3.0	4.0	5.0	4.0
	Mean	3.8	3.0	4.5	3.8
		Means of organic material treatments			
	M_1	39.9	31.3	43.2	38.1
	M_2	45.4	42.9	45.9	44.7
Grand mean		42.7	37.1	44.6	

<u>LSD (0.05):</u>

M=0.63; R=0.77; S=0.77; MR=1.09; MS=1.09; RS=1.34; MRS=1.90

<u>LSD (0.01):</u>

M=1.31; R=1.60; S=1.60; MR=2.27; MS=2.27; RS=2.78; MRS=3.93

M_1 = rice straw compost; M_2 = peatmoss

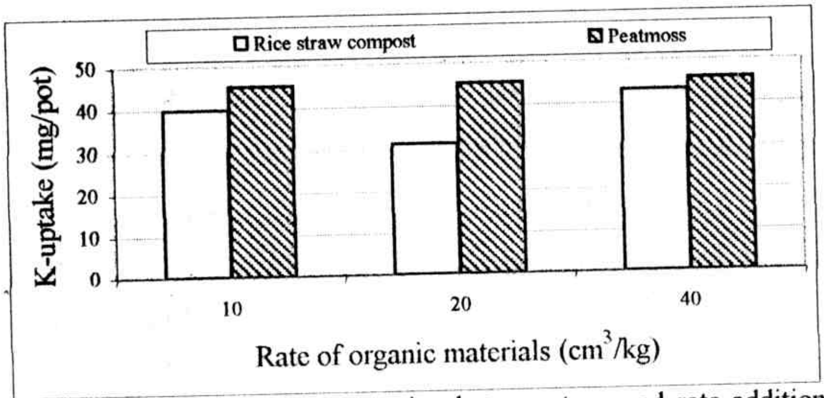

Fig. (41a): Effect of the interaction between type and rate addition of organic material on K-uptake by grain yield.

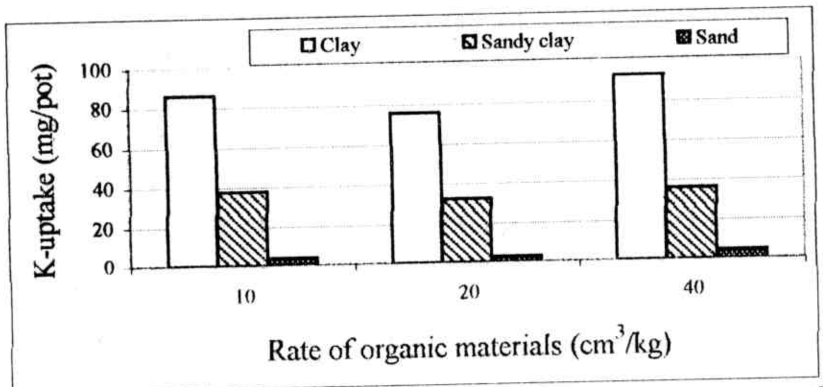

Fig. (41b): Effect of the interaction between addition rates of organic materials and soil type on K-uptake by grain yield.

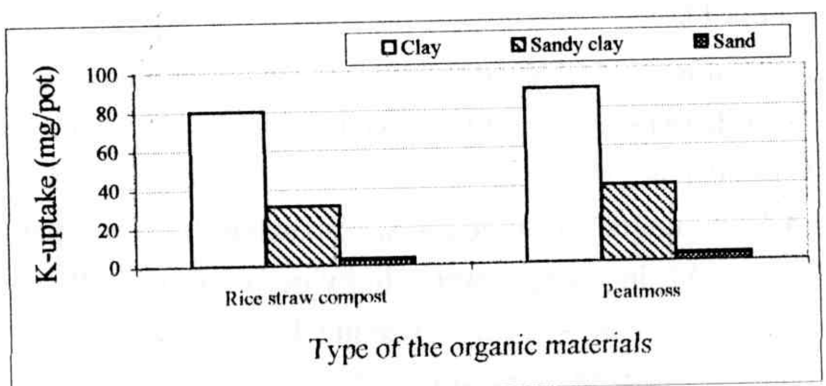

Fig. (40c): Effect of the interaction between the type of organic materials and soil type on K-uptake by grain yield.

M_2 over M_1 was 14.29 %. The highest K-uptake by the grain yield given by the rates of organic material was in general, that given by R_3 in most cases.

K-uptake by straw "Table 39 and Fig. 42":

Straw compost (M_1) gave an average a slight increase of 4.08 % K-uptake by straw yield over peatmoss (M_2). The increase of M_1 over M_2 occurred particularly at R_1 and R_3 being 4.02 % and 25.27 % in the two rates, respectively. The superiority of M_1 over M_2 in giving greater K-uptake by straw yield was most marked in the clay soil, giving 18.21 % increase on average. In the sandy clay soil and the sand soil, it was M_2, which surpassed M_1, giving 12.71 increase on average in the former and 65.22 % in the latter. The highest K-uptake by straw yield given by the rates of organic material was in general, that given by either R_3 or R_2 in most cases.

EC of soil paste extract "Table 23 of appendix 1 and Fig. 43":

Values of EC were measured at end of experiment. The general trend of salinity before start of experiment and its end shows a decrease in salinity (compare table 1 with table 23 of Appendix 1).

Peatmoss (M_2) gave in general, an EC, which was lower by 33.71 % than straw compost (M_1) on average. Such lower EC by M_2 under M_1 occurred at R_1, R_2 and R_3, being 57.03, 30.65 and 4.53 % under the three rates, respectively. The superiority of M_2 over M_1 in giving lower salinity occurred in the three soils particularly the clay soil (S_1) reflecting 47.75 % lower salinity on average. In the sandy clay soil (S_2), M_2 showed 28.19 % lower

Table (39): Comparative effect of adding rice straw compost or peatmoss to light and heavy soils on K-uptake (mg/pot) by straw yield of wheat irrigated with saline water (3.59 dS/m).

Soil [S]	Organic materials [M]	Rate of organic materials (cm^3/kg soil)			
		10	20	40	Mean
Clay	M_1	37.9	30.9	54.0	40.9
	M_2	33.5	36.1	34.3	34.6
	Mean	35.7	33.5	44.2	37.8
Sandy clay	M_1	22.3	18.2	13.9	18.1
	M_2	23.0	20.7	17.5	20.4
	Mean	22.7	19.5	15.7	19.3
Sand	M_1	1.9	2.9	2.0	2.3
	M_2	3.1	4.1	4.1	3.8
	Mean	2.5	3.5	3.1	3.0
		Means of organic material treatments			
	M_1	20.7	17.3	23.3	20.4
	M_2	19.9	20.3	18.6	19.6
Grand mean		20.3	18.8	21.0	

LSD (0.05):
M=0.43; R=0.53; S=0.53; MR=0.75; MS=0.75; RS=0.92; MRS=1.30
LSD (0.01):
M=0.89; R=1.10; S=1.10; MR=1.55; MS=1.55; RS=1.90; MRS=2.69

M_1 = rice straw compost; M_2 = peatmoss

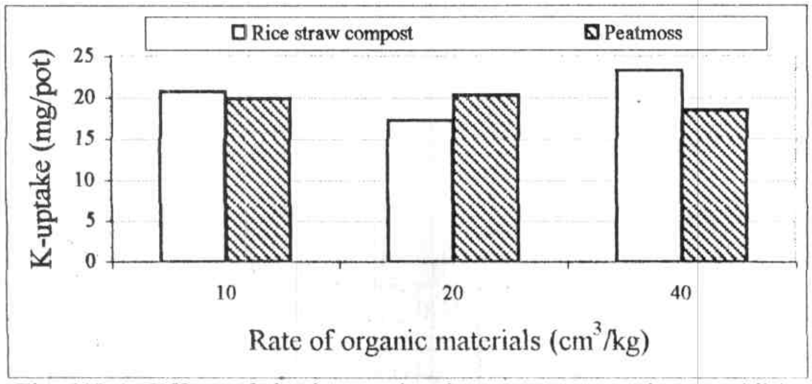

Fig. (42a): *Effect of the interaction between type and rate addition* of organic material on K-uptake by straw yield.

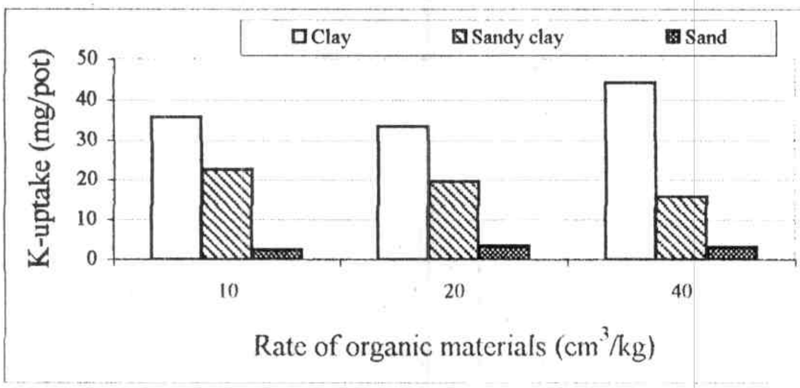

Fig. (42b): Effect of the interaction between addition rates of organic materials and soil type on K-uptake by straw yield.

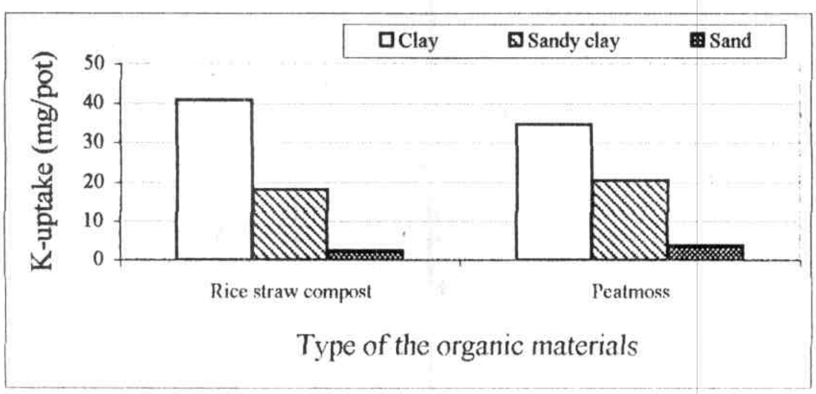

Fig. (42c): Effect of the interaction between the type of organic materials and soil type on K-uptake by straw yield.

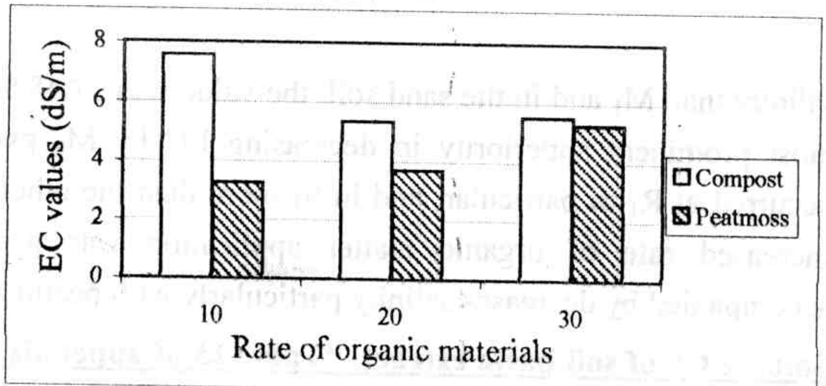

Fig. (43a): *Interaction between addition of organic materials and their rates on EC of soil paste extract.*

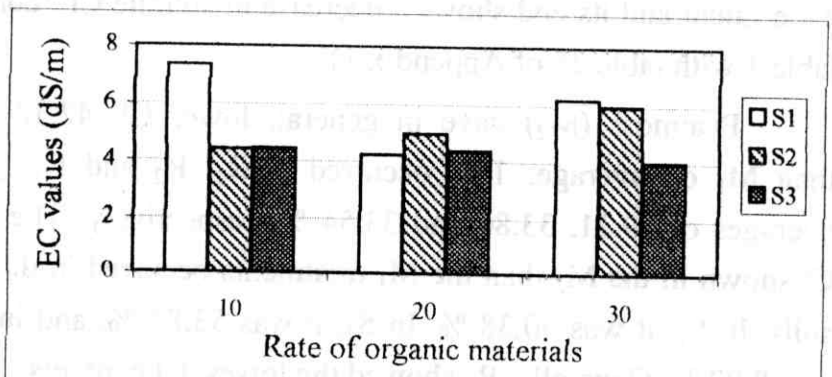

Fig. (43b): Interaction between addition rates of organic materials and soil type on EC of soil paste extract.

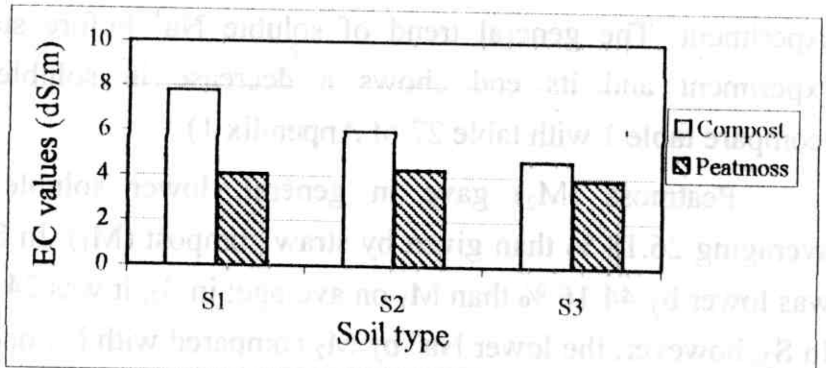

Fig. (43c): *Interaction between addition of organic materials and soil type on EC of soil paste extract.*

salinity than M_1 and in the sand soil, the value was 17.48 %. The most prominent superiority in decreasing EC by M_2 over M_1 occurred at R_1 in particular, and in S_1 more than the other soils. Increased rate of organic matter application was generally accompanied by decreases salinity particularly with peatmoss.

Soluble Cl^- of soil paste extract "Table 25 of appendix 1 and Fig. 44":

Values of soluble Cl^- were measured at end of experiment. The general trend of soluble Cl^- before start of experiment and its end shows a decrease in soluble Cl^- (compare table 1 with table 25 of Appendix 1).

Peatmoss (M_2) gave in general, lower Cl, 42.38 lower than M_1 on average. This occurred at R_1, R_2 and R_3, giving averages of 59.21, 33.86 and 33.54 %, respectively. The lower Cl shown in the M_2 than the M_1 treatments occurred in the three soils. In S_1, it was 50.38 %. In S_2, it was 53.83 %, and in S_3, it was 8.90 %. Generally, R_1 showed the lowest Cl contents.

Soluble Na^+ of soil paste extract "Table 27 of appendix 1 and Fig. 45":

Values of soluble Na^+ were measured at end of experiment. The general trend of soluble Na^+ before start of experiment and its end shows a decrease in soluble Na^+ (compare table 1 with table 27 of Appendix 1).

Peatmoss (M_2) gave in general, lower soluble Na^+, averaging 26.18 % than given by straw compost (M_1). In S_1, M_2 was lower by 44.16 % than M_1 on average; in S_2, it was 24.26 %. In S_3, however, the lower Na^+ by M_2 compared with M_1 occurred

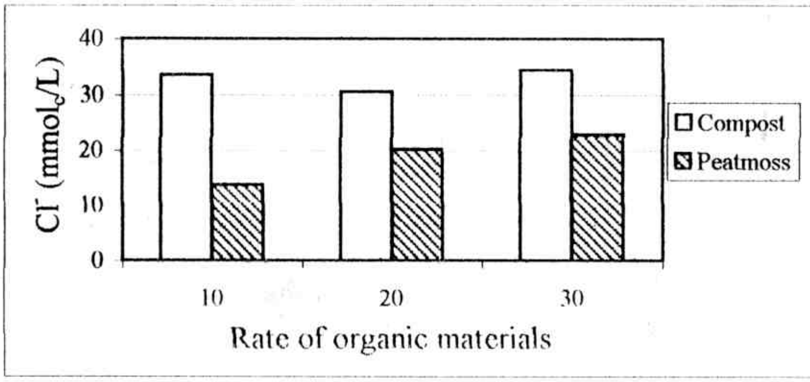

Fig. (44a): Interaction between addition of organic materials and their rates on soluble Cl^- of soil paste extract.

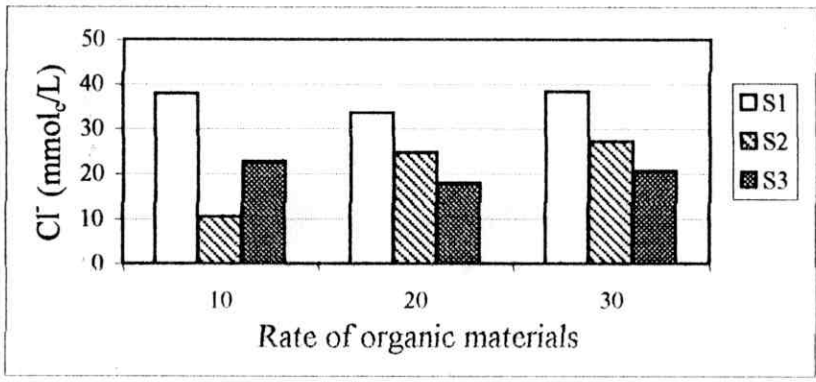

Fig. (44b): Interaction between addition rates of organic materials and soil type on soluble Cl^- of soil paste

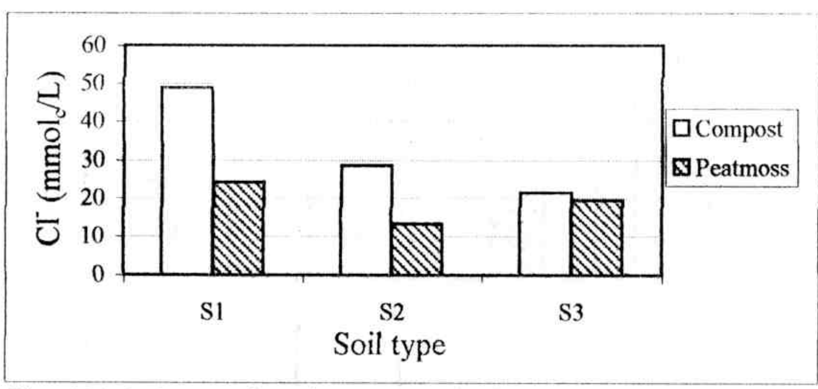

Fig. (44c): Interaction between addition of organic materials and soil type on soluble Cl^- of soil paste extract.

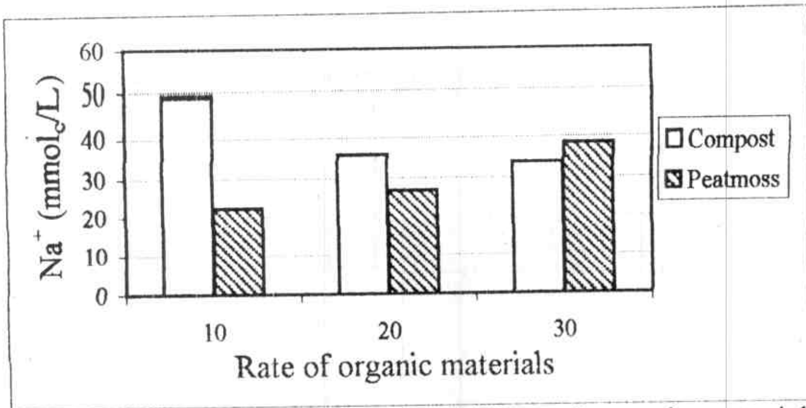

Fig. (45a): Interaction between addition of organic materials and their rates on soluble Na^+ of soil paste extract.

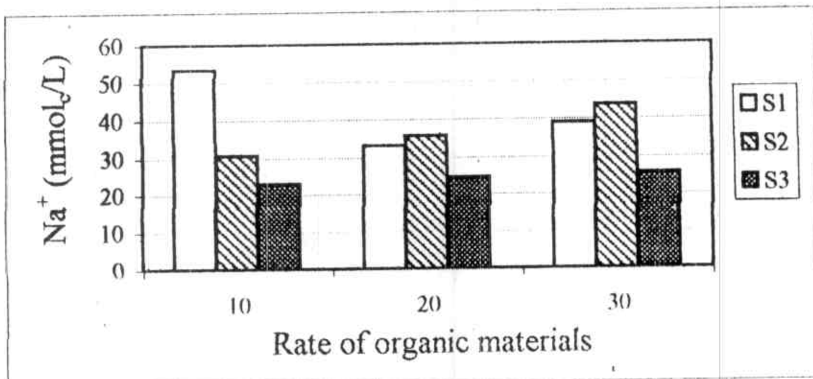

Fig. (45b): Interaction between addition rates of organic materials and soil type on soluble Na^+ of soil paste

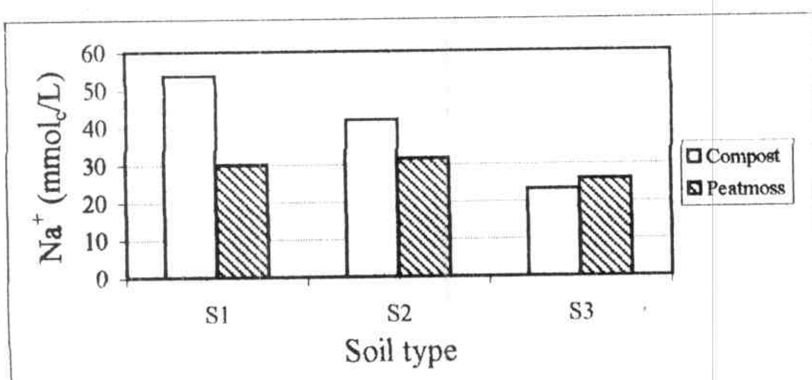

Fig. (45c): Interaction between addition of irganic materials and soil type on soluble Na^+ of soil paste extract.

at R_1 and R_2. Generally, R_2 in most cases was the most effective in reducing soluble Na^+.

Conclusive assessment on results of experiment 3: effect of organic amendment on alleviating salinity stress:

Peatmoss, due to its low bulk density and high capacity for water absorption would be of greater positive effect in alleviating salinity stress. This was reflected in the greater grain yields in particular; and in the light-textured soils in particular. The lower EC in soil water of the peatmoss-treated soils than in the straw-compost-treated ones is a reflection of the greater absorption capacity for water of peatmoss than straw-compost. Also, adding peatmoss to soils would increase the adsorption capacity of soil more than in the case of straw-compost.

Experiment 4: leaching treatment:

Three leaching treatments were used in this experiment. They may be considered as leaching fractions of 0.1, 0.3 and 0.5. Irrigations for these fractions were done so as to exceed the water-holding capacity by 10, 30 and 50 % in each irrigation. Treatment codes for these fractions are L_1, L_2 and L_3, respectively. Alfalfa plant was used as an indicator plant in this experiment.

Alfalfa total yield "Table 40 and Fig. 46":

Alfalfa total yield increased by decreasing leaching fraction (L). The increase was greatest at leaching fraction 0.10 L_1. Both leaching fractions 0.10 (L_1) and 0.30 (L_2) gave nearly the same as for alfalfa total yield, and were significantly higher yields than total yield of alfalfa obtained by 0.50 leaching fraction (L_3). The increases were 37.13 % and 27.43 % upon using (L_1) and (L_2) leaching fractions, respectively in comparison with the yield obtained by (L_3). In the clay soil, the highest alfalfa total yield was obtained at L_1, and both L_1 and L_2 were higher than alfalfa total yield obtained by L_3. The increases were 56.49 and 24.44 % upon using L_1 and L_2, respectively in comparison with alfalfa total yield obtained by L_3. Leaching of L_2 and L_3 may led to greater loss of nutrients from the root zone, it may have also decreased aeration in the root zone and consequently negatively affecting root respiration and decreasing plant growth process. In sandy clay soil, L_2 give the highest alfalfa total yield. The increase was 33.26 % of alfalfa total yield upon using L_2 over yields of either L_1 or L_3. It seems that in this soil irrigation with the L_2 was more suitable for plant growth and

Table (40): Effect of leaching requirement with using light and heavy soils on total yield (g/pot) of alfalfa irrigated with saline water (3.59 dS/m).

Soil [S]	Leaching requirement (L) as a fraction of complete water holding capacity			
	L_1=0.10	L_2=0.30	L_3=0.50	Mean
Clay (S_1)	13.38	10.64	8.55	10.86
Sandy clay (S_2)	4.42	5.89	4.42	4.91
Mean	8.90	8.27	6.49	
LSD (0.05):	S = 0.60	L = 0.74	L×S = 1.04	
LSD (0.01):	S = 0.85	L = 1.05	L×S = 1.75	

Table (41): Effect of leaching requirement with using light and heavy soils on N-uptake (mg/pot) by total yield of alfalfa irrigated with saline water (3.59 dS/m).

Soil [S]	Leaching requirement (L) as a fraction of complete water holding capacity			
	L_1=0.10	L_2=0.30	L_3=0.50	Mean
Clay (S_1)	716	652	632	667
Sandy clay (S_2)	260	361	224	282
Mean	488	507	428	
LSD (0.05):	S = 1.39	L = 1.69	L×S = 2.40	
LSD (0.01):	S =1.97	L = 2.40	L×S = 3.41	

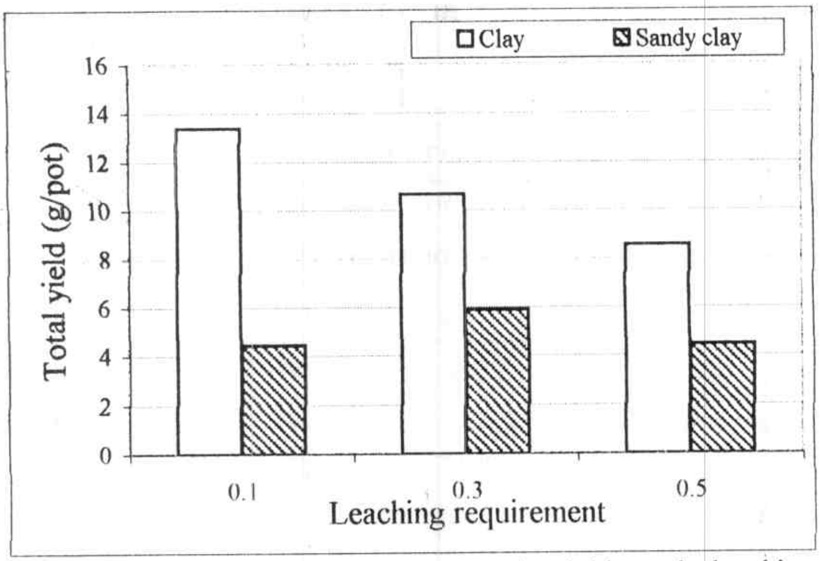

Fig. (46): Relationship between total yield and leaching requirement as a fraction of water holding capacity.

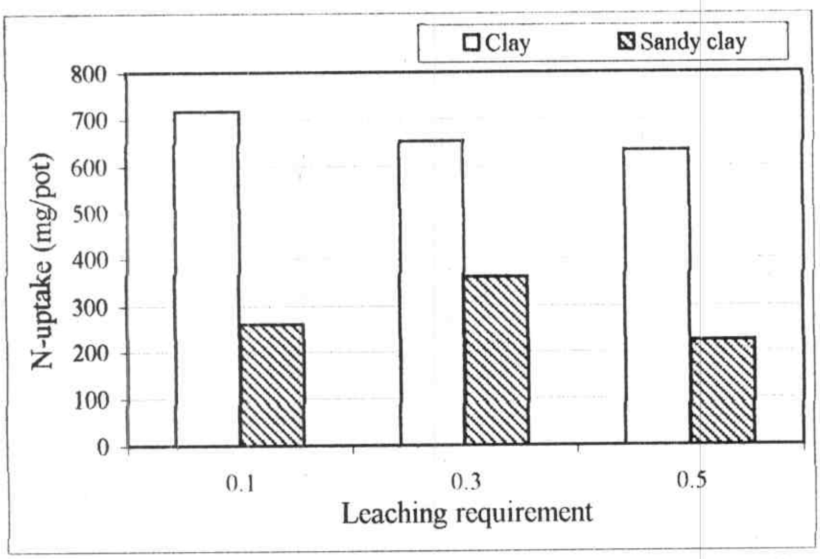

Fig. (47): Relationship between N-uptake and leaching requirement as a fraction of water holding capacity.

neither L_1 nor L_3 was enough for maximum growth of plants. **Ibrahim (1992)**, reported increased tomato growth and yield using 0.25 leaching fraction over 0.10 leaching fraction and attributed this to a reduction in soil salinity.

N-uptake by alfalfa yield "Table 41 and Fig. 47":

Results of N-uptake by alfalfa were in line with the results of alfalfa yield. N-uptake by alfalfa yield increased with increasing leaching fraction till L_2, but it decreased at L_3. The increase was greatest at L_2 leaching fraction. Both leaching fractions L_1 and L_2 gave significantly higher N-uptake over the L_3 treatment. Increases were 14.02 and 18.46 % upon using L_1 and L_2 leaching fractions, respectively in comparison with L_3. This pattern of N-uptake by alfalfa yield was most marked in sandy clay soil where the greater uptake by L_1 and L_2 over L_3 were 16.07 % and 61.16 %, respectively. Therefor, N-uptake by alfalfa was greatest at L_2 in the sandy clay soil. The L_3 treatment must have caused an adverse effect particularly in the sandy clay soil. In the clay soil, L_1 and L_2 gave 13.29 and 3.16 %, respectively higher N-uptake by alfalfa yield over L_3. Therefore, especially in the clay soil, increasing the amount of leaching fraction was of adverse effect in comparison with L_1 and L_2.

P-uptake by alfalfa yield "Table 42 and Fig. 48":

The pattern of P-uptake was in line with that of yield and N-uptake. P-uptake by alfalfa yield increased by decreasing leaching fractions. The increase was greatest at L_1 leaching fraction. Average increases were 43.60 and 31.24 % upon using L_1 and L_2, respectively over L_3 leaching fraction. This pattern of P-uptake by alfalfa was most marked in the clay soil, giving

Table (42): Effect of leaching requirement with using light and heavy soils on P-uptake (mg/pot) by total yield of alfalfa irrigated with saline water (3.59 dS/m).

Soil [S]	Leaching requirement (L) as a fraction of complete water holding capacity			
	L_1=0.10	L_2=0.30	L_3=0.50	Mean
Clay (S_1)	43.64	34.30	26.42	34.79
Sandy clay (S_2)	14.92	19.22	14.36	16.17
Mean	29.28	26.76	20.39	
LSD (0.05):	S = 0.56	L = 0.69	L×S = 0.98	
LSD (0.01):	S =0.80	L = 0.99	L×S = 1.39	

Table (43): Effect of leaching requirement with using light and heavy soils on K-uptake (mg/pot) by total yield of alfalfa irrigated with saline water (3.59 dS/m).

Soil [S]	Leaching requirement (L) as a fraction of complete water holding capacity			
	L_1= 0.10	L_2= 0.30	L_3= 0.50	Mean
Clay (S_1)	119.8	88.8	76.4	95.0
Sandy clay (S_2)	32.1	45.2	34.8	37.4
Mean	76.0	67.0	55.6	
LSD (0.05):	S = 0.94	L = 1.15	L×S = 1.63	
LSD (0.01):	S = 1.34	L = 1.64	L×S = 2.31	

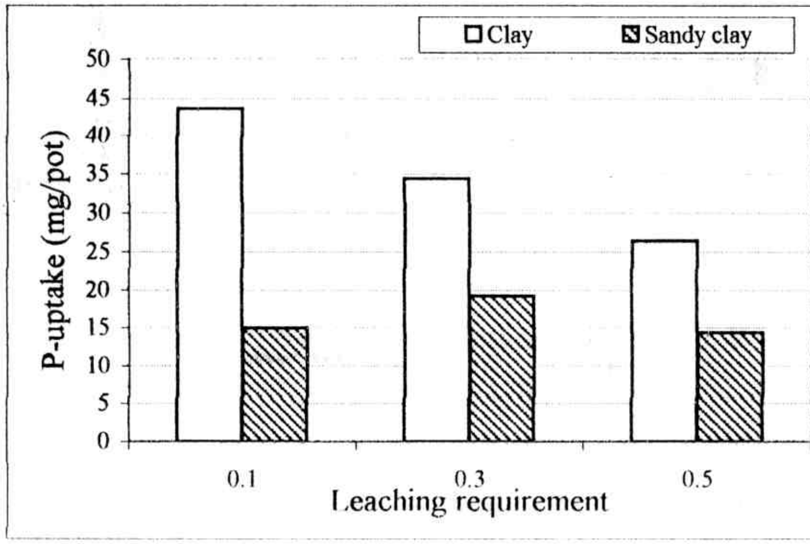

Fig. (48): Relationship between P-uptake and leaching requirement as a fraction of water holding capacity.

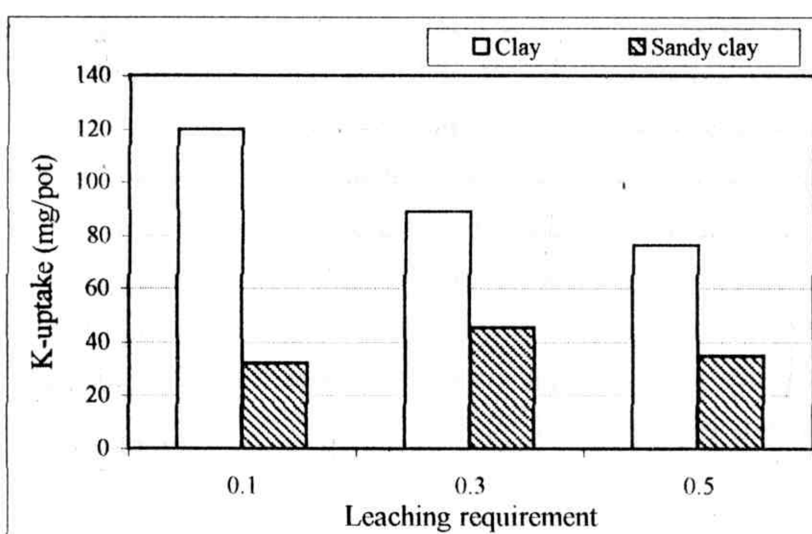

Fig. (49): Relationship between K-uptake and leaching requirement as a fraction of water holding capacity.

65.18 and 29.83 % greater P-uptake by L_1 and L_2 over L_3. Particularly in the clay soil, increasing leaching fractions is associated with increases in the amount of soil water especially in the root zone, creating low aeration for the root respiration, hence lowering the nutrient availability to uptake by the plant. **Curtin et al. (1992)** studied the effect of salinity and sodicity of irrigation water on solubility of native P in soils, and found that leachate P decreased as salinity of water increased especially with high SAR levels.

K-uptake by alfalfa yield "Table 43 and Fig. 49":

K-uptake by alfalfa yield increased by decreasing the leaching fractions. The increase was greatest with L_1 followed by L_2 giving 36.69 and 20.50 % greater K-uptake, respectively over L_3. This pattern of K-uptake by alfalfa yield was most marked in the clay soil where L_1 and L_2 gave 56.81 and 16.23 % greater K-uptake, respectively over L_3. Therefore, the clay soil showed greater differences between the leaching treatments. In the clay soil, a rise in the water content within the root zone of the plant would create conditions of low aeration for respiring the roots, thus reducing the uptake process of the nutrient to the plant. In the sandy clay soil, the greatest K-uptake by alfalfa yield occurred at L_2. The L_2 in this soil was the most optimum for K-uptake. **Anter (1963), Mahrous et al. (1983), Devitte et al. (1981) and El-Toukhy (1987)**, reported that, soils of high salinity showed high contents of water soluble and ammonium acetate extractable K.

EC of soil paste extract "Table 32 of appendix 1 and Fig. 50":

Values of EC were measured at end of experiment. The general trend of salinity before start of experiment and its end shows a decrease in salinity (compare table 1 with table 32 of Appendix 1).

EC of soil paste extract decreased with application leaching treatments. The decrease was not progressive with increasing leaching fraction. The lowest decrease occurred at 0.3 leaching fraction L_2. The lower EC of L_2 and L_3 in comparison with L_1 amounted to 40.77 and 11.15 %, respectively on average. This pattern of decrease in EC of soil paste extract with the increase in leaching was most marked in the clay soil (S_1) where L_2 and L_3 were 47.71 and 40.67 %, respectively lower in EC in comparison with L_1. In S_2 however, EC at L_3 did not show lower EC than L_1, but L_2 showed 31.70 % lower salinity. In this particular S_2 soil, L_3 showed 28.05 % increase in soil salinity.

Soluble Cl^- of soil paste extract "Table 34 of appendix 1 and Fig. 51":

Values of soluble Cl^- were measured at end of experiment. The general trend of soluble Cl^- before start of experiment and its end shows a decrease in soluble Cl^- (compare table 1 with table 34 of Appendix 1).

Soluble Cl^- of the soil paste extract either at L_1 or L_2 was similar. In the clay soil, the lowest soluble Cl^- obtained at 0.10 leaching fraction (L_1). However, in the sandy clay soil, soluble Cl^- of soil paste extract decreased by 23.88 % upon applying leaching fraction (L_2) in comparison with that obtained at (L_1)

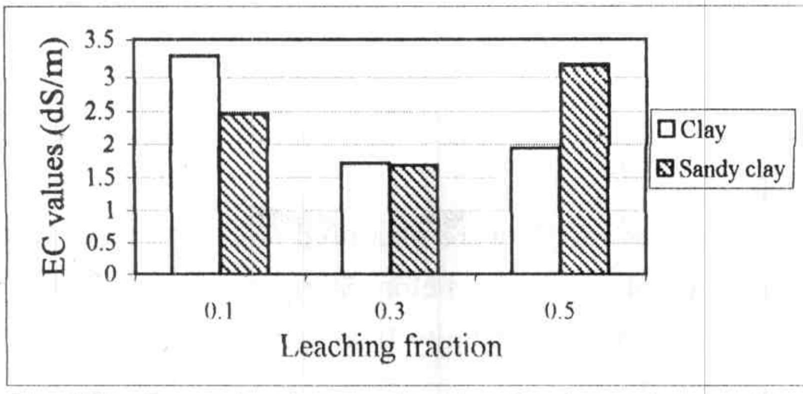

Fig. (50): *Interaction between leaching fraction and type of soil irrigated with saline water on EC of soil paste extract.*

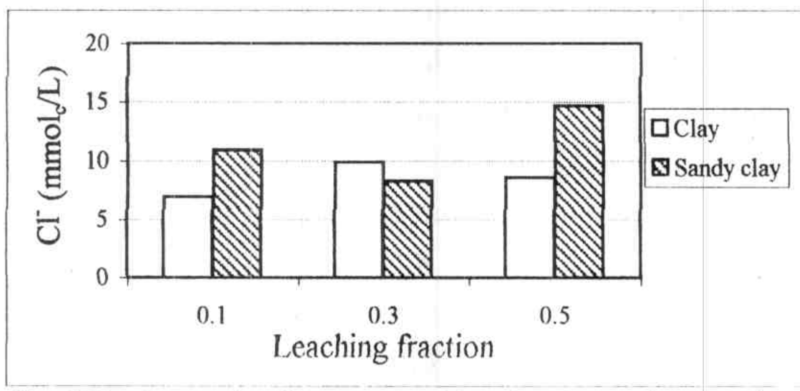

Fig. (51): Interaction between leaching fraction and type of soil irrigated with saline water on soluble Cl^- of soil paste extract.

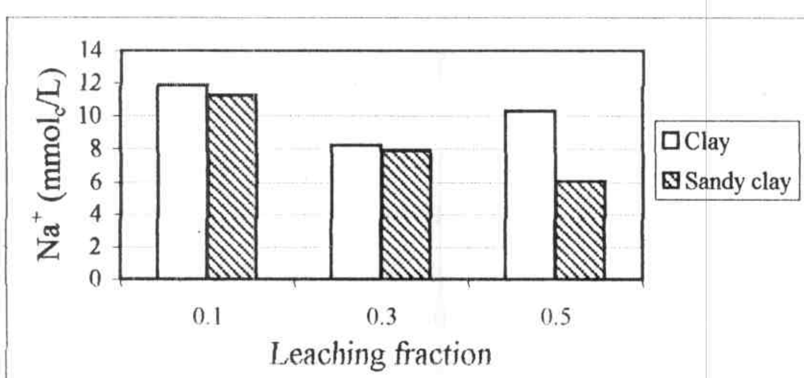

Fig. (52): Interaction between leaching fraction and type of soil irrigated with saline water on soluble Na^+ of soil paste extract.

leaching fraction. Soluble Cl^- was greater in L_2 and L_3 by average of 1.91 and 30.45 %, respectively over L_1. This was particularly marked in the clay soil (S_1) where the values of greater Cl^- were 42.40 and 23.39 % by L_2 and L_3, respectively over L_1. In the sand soil (S_2), it was L_3, which was effective in increasing Cl^- in soil. The S_2 soil showed greater Cl^- than The S_1 soil.

<u>Soluble Na^+ of soil paste extract "Table 36 of appendix 1 and Fig. 52":</u>

Values of soluble Na^+ were measured at end of experiment. The general trend of soluble Na^+ before start of experiment and its end shows a decrease in soluble Na^+ (compare table 1 with table 36 of Appendix 1).

Increased leaching decreased soluble Na^+ of the soil paste extract. The L_2 and L_3 showed 30.38 and 29.18 % less Na^+, respectively compared with L_1 on average. The lower Na^+ by increased leaching was most marked in S_2, where L_2 and L_3 showed less sodicity by 30.11 and 46.18 %, respectively in comparison with L_1; in S_1 comparable values are 30.74 and 13.09 %, respectively.

<u>Conclusive assessment on results of experiment 4: effect of leaching on alleviating salinity stress:</u>

Although application of irrigation water in excess of evapotranspiration helps in preventing salinity build-up, when such practice is done using excess leaching it could lead to a negative outcome on plant growth. Applying leaching treatments in excess of 0.1 leaching fraction, although it decreased salinity build-up in soil, it seemed to have depleted the soil of plant nutrients and/or created unfavorable conditions for plant growth. Therefore using such practice should be carefully assessed.

Experiment 5: mulching

In this experiment, three mulching materials were used, i.e., plastic sheet, rice straw material and coarse sand. Alfalfa plant was used as an indicator plant.

Alfalfa total yield "Table 44 and Fig. 53":

Alfalfa total yield increased upon using plastic sheet (C_2) and coarse sand (C_4) mulching materials. However, rice straw mulching material (C_3) gave the lowest alfalfa total yield, nearly the same as the control (C_1) (i.e., no mulching). The greatest alfalfa total yield was obtained with using C_4 mulching material. The C_2 and C_4 mulching materials gave increases total than the non-mulching treatment of 17.26 and 52.94 %, respectively. This pattern of response to the mulching was most marked in both soils (i.e., the sandy clay soil and the sand soil). In the sandy clay soil, increases in alfalfa total yield were 15.69 and 47.93 % upon using C_2 and C_4 mulching materials. In the sand soil, increases in alfalfa total yield were 31.37 and 96.08 % upon using C_2 and C_4 mulching materials. Thus, using coarse sand and plastic sheet are more efficient than rice straw in obtaining high yields under condition of using saline water for irrigation. **Jo et al. (1993)** found that growing crops on newly reclaimed saline soils was improved and yields increase upon adding sand on the soil surface. They added that with increased thickness of sand mulch cotton yields increased following the order of 1 cm > 5 cm > 10 cm of sand mulching and that growth of tall fescue fodder crop (*Festuca arundinacea*) were greatest with 3 cm thickness of sand mulch. **Marcar et al. (2000)** conducted 4 trials on 2 dryland saline soils using wheat straw, wood chips, rice husks and plastic

Table (44): Comparative effect of using mulching materials to light soils on total yield (g/pot) of alfalfa irrigated with saline water (3.59 dS/m).

Soil [S]	Mulching materials [C]				
	Non-mulching (C_1)	Plastic sheet (C_2)	Rice straw (C_3)	Coarse sand (C_4)	Mean
Sandy clay (S_1)	4.59	5.31	4.33	6.79	5.26
Sand (S_2)	0.51	0.67	0.54	1.00	0.68
Mean	2.55	2.99	2.44	3.90	
LSD (0.05):	S = 0.18	C = 0.25		S×C = 0.35	
LSD (0.01):	S = 0.24	C = 0.34		S×C = 0.49	

Table (45): Comparative effect of using mulching materials to light soils on N-uptake (mg/pot) by total yield of alfalfa irrigated with saline water (3.59 dS/m).

Soil [S]	Mulching materials [C]				
	Non-mulching (C_1)	Plastic sheet (C_2)	Rice straw (C_3)	Coarse sand (C_4)	Mean
Sandy clay (S_1)	222	335	282	674	378
Sand (S_2)	3	5	4	13	6
Mean	113	170	143	344	
LSD (0.05):	S = 0.61	C = 0.86		S×C = 1.21	
LSD (0.01):	S = 0.84	C = 1.19		S×C = 1.68	

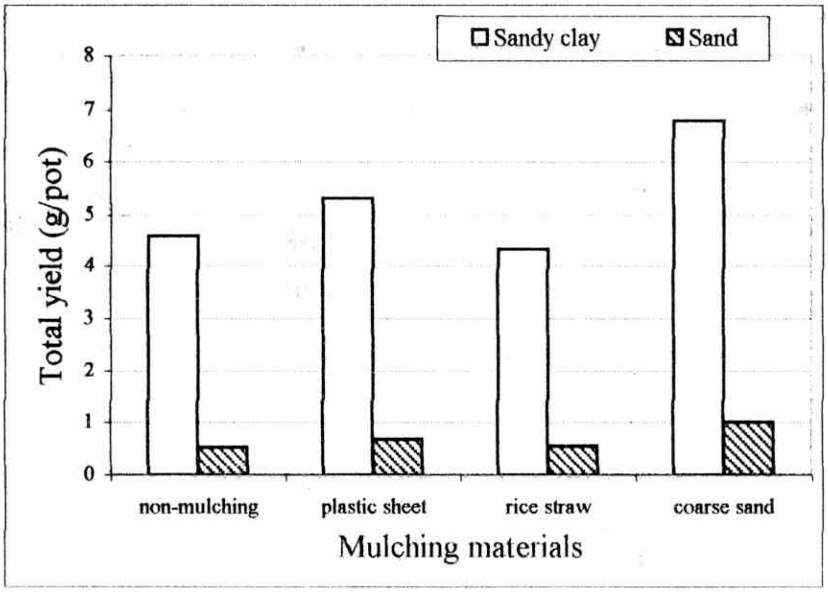

Fig. (53): Relationship between total yield and mulching materials.

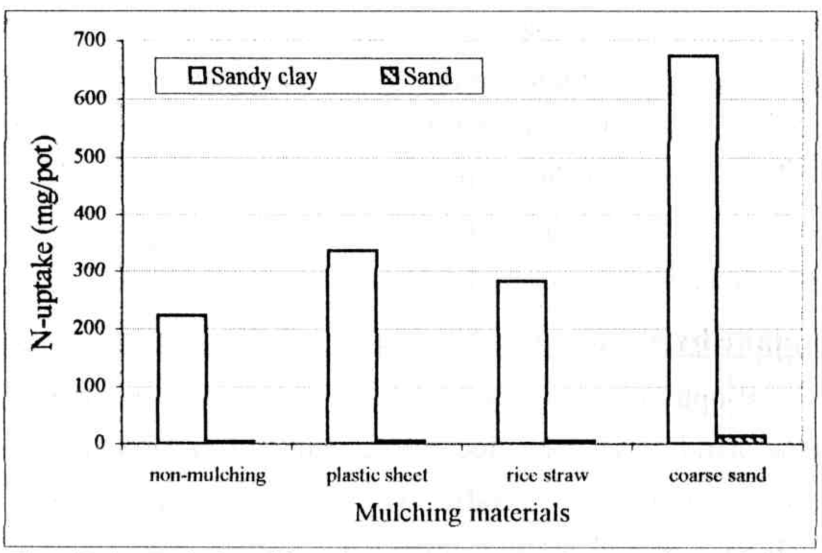

Fig. (54): Relationship between N-uptake and mulching materials.

sheet) and studied the effect on survival and growth of *Acacia Stenophylla, Atriplex nummularia, Casuarina cunninghamiana, Eucalyptus camaldulensis and Melaleuca halmaturorum*. They found that mulching showed variable effects, depending on species and soil and that it was of positive effects on plant height particularly plastic mulch. The combined effect of mulch and fertilizer on growth gave the most effective results.

N-uptake by alfalfa yield "Table 45 and Fig. 54":

The pattern of response was rather similar to that of the yield. N-uptake by alfalfa increased with using all types of mulching materials. N-uptake by alfalfa yield was the greatest with using coarse sand mulching material (C_4). Increases were 50.44, 26.55 and as high as 204.43 % upon using C_2, C_3 and C_4 mulching materials, respectively. Plastic sheet mulching material (C_2) gave higher N-uptake than the rice straw mulching material (C_3). In the sandy clay soil, increases of N-uptake by alfalfa yield were 50.9, 27.03 and 203.6 % upon using C_2, C_3 and C_4 mulching materials, respectively. In the sand soil, increases of N-uptake by alfalfa yield were 66.67, 33.33 and 76.92 % upon using C_2, C_3 and C_4 mulching materials. **Nakhlla and Ghali (1996)** reported soil N, P and K increased with increasing mulch cover of perforated polyethylene, and that N-concentration in orange trees roots were highest using mulch cover.

P-uptake by alfalfa yield "Table 46 and Fig. 55":

P-uptake by alfalfa increased using plastic sheet (C_2) and coarse sand (C_4), but decreased using rice straw (C_3). The greatest P-uptake by alfalfa was obtained using coarse sand mulching material (C_4). P-uptake by alfalfa increased by 8.46

Table (46): Comparative effect of using mulching materials to light soils on P-uptake by total yield of alfalfa irrigated with saline water (3.59 dS/m).

Soil [S]	Mulching materials [C]				
	Non-mulching (C_1)	Plastic sheet (C_2)	Rice straw (C_3)	Coarse sand (C_4)	Mean
Sandy clay (S_1)	16.00	17.46	13.70	24.43	17.90
Sand (S_2)	1.01	1.00	1.02	1.00	1.01
Mean	8.51	9.23	7.36	12.72	
LSD (0.05):	S = 0.37	C = 0.53		S×C = 0.74	
LSD (0.01):	S = 0.52	C = 0.73		S×C = 1.03	

Table (47): Comparative effect of using mulching materials to light soils on K-uptake (mg/pot) by total yield of alfalfa irrigated with saline water (3.59 dS/m).

Soil [S]	Mulching materials [C]				
	Non-mulching (C_1)	Plastic sheet (C_2)	Rice straw (C_3)	Coarse sand (C_4)	Mean
Sandy clay (S_1)	42.7	43.2	42.1	64.9	48.2
Sand (S_2)	1.0	1.0	1.0	1.0	1.0
Mean	21.9	22.1	21.6	33.0	
LSD (0.05):	S = 0.35	C = 0.49		S×C = 0.69	
LSD (0.01):	S = 0.48	C = 0.68		S×C = 0.96	

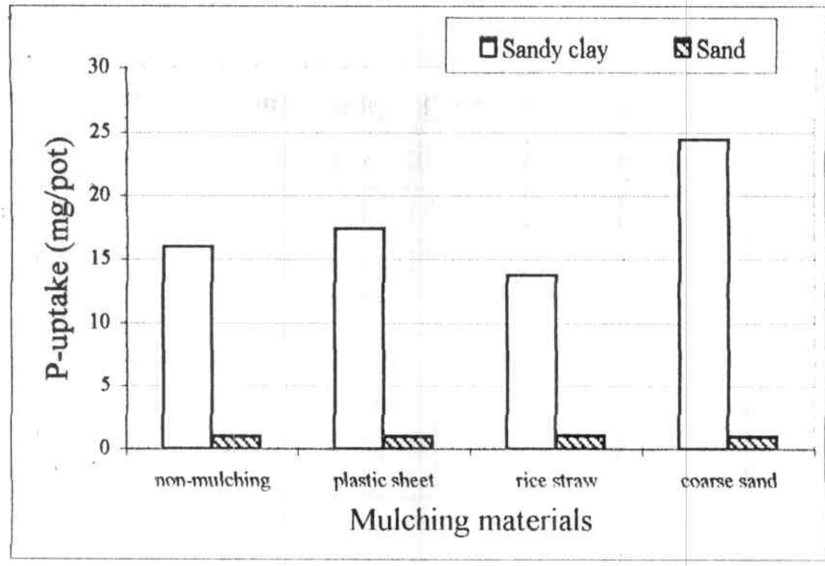

Fig. (55): Relationship between P-uptake by alfalfa plant and mulching materials.

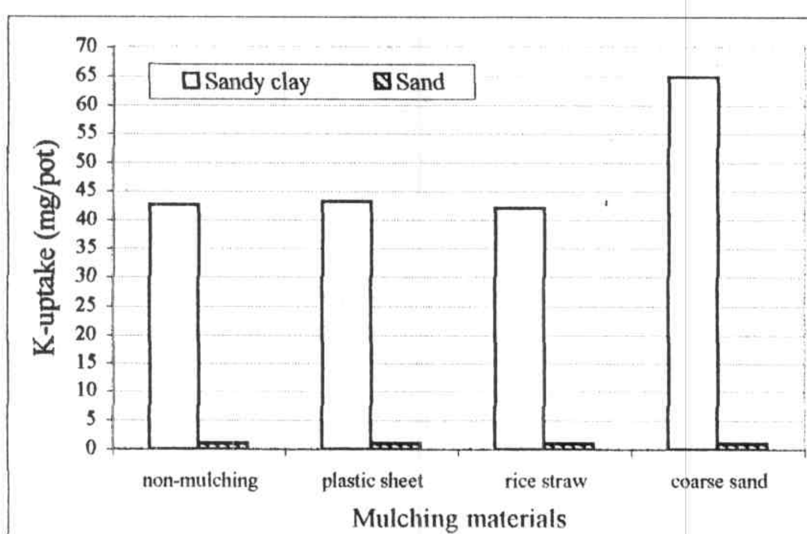

Fig. (56): Relationship between K-uptake by alfalfa plant and mulching materials.

and 49.47 % upon using C_2 and C_4 mulching materials, respectively. This pattern of response to mulching was most marked in the sandy clay soil, giving increases of 9.12 and 52.69 % upon using C_2 and C_4 mulching materials, respectively. In the sand soil, no significant differences were found between any mulching material treatments including the no mulching. **Nakhlla and Ghali (1996)** reported that available P increased with increasing mulch cover of perforated polyethylene and that P-concentration in orange trees roots was highest using mulch cover.

K-uptake by alfalfa yield "Table 47 and Fig. 56":

K-uptake by alfalfa yield increased significantly using the coarse sand mulching material (C_4). The increase was 50.69 % upon using coarse sand mulching material (C_4); other materials showed little or no effect. This pattern response to mulching was most marked in the sandy clay soil, giving 51.99 % increase on the average upon using coarse sand (C_4) mulching material. In the sand soil, there was no significant response to mulching. **Nakhlla and Ghali (1996)** reported that available K increased with increasing mulch cover of perforated polyethylene and that K-concentration in orange tress roots was highest using mulch cover.

EC of soil paste extract "Table 41 of appendix 1 and Fig. 57":

Values of EC were measured at end of experiment. The general trend of salinity before start of experiment and its end shows a decrease in salinity (compare table 1 with table 41 of Appendix 1).

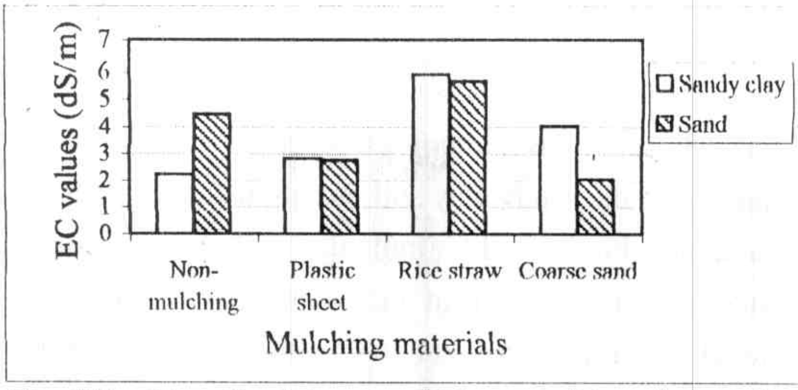

Fig. (57): *Interaction between mulching materials and type of soil* irrigated with saline water on EC of soil paste extract.

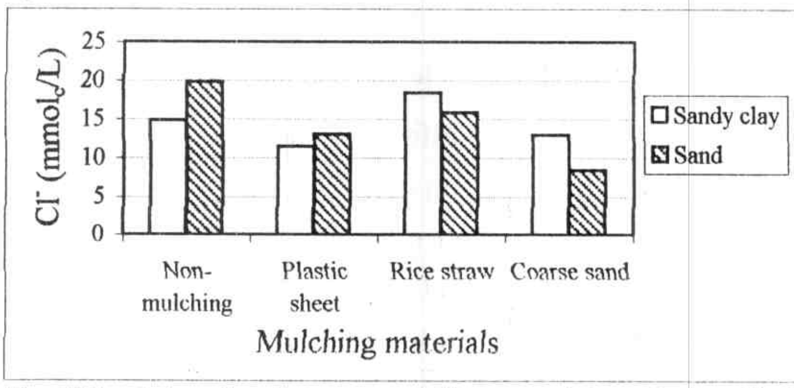

Fig. (58): Interaction between mulching materials and type of soil irrigated with saline water on soluble Cl^- of soil paste extract.

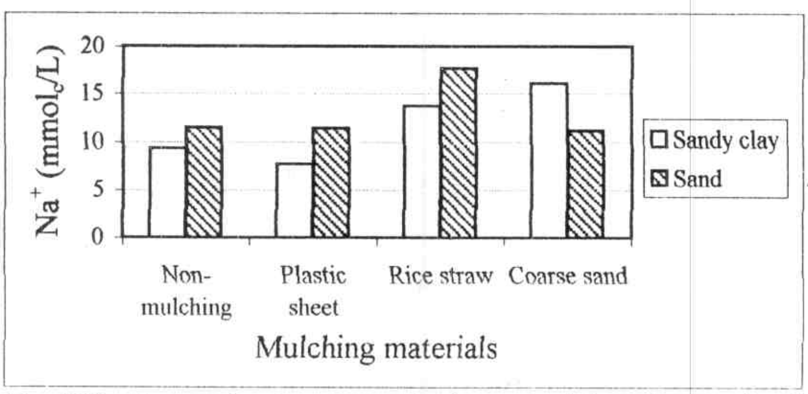

Fig. (59): Interaction between mulching materials and type of soil irrigated with saline water on soluble Na^+ of soil paste extract.

Mulching with either plastic sheet (C_2) or with coarse sand (C_4) in particular decreased EC of soil paste extract by averages of 16.67 and 9.82 %, respectively. Such trend of response to mulching with C_2 and C_4 was most marked in the sand soil (S_2), giving 38.53 and 54.57 % upon applying C_2 and C_4, respectively. Rice straw mulch (C_3) however was associated with increased salinity, an average of 72.20 %. In the sandy clay soil, there was an increase in salinity by mulching with all materials.

Soluble Cl^- of soil paste extract "Table 43 of appendix 1 and Fig. 58":

Values of soluble Cl^- were measured at end of experiment. The general trend of soluble Cl^- before start of experiment and its end shows a decrease in soluble Cl^- (compare table 1 with table 43 of Appendix 1).

Mulching with all mulching materials decreased soluble Cl^- in soil particularly with C_2 and C_4. The lowest Cl^- was with coarse sand (C_4). Average decreases in soluble Cl^- were 29.39, 1.27 and 38.39 % upon applying C_2, C_3 and C_4 mulching materials, respectively. This pattern of response to mulching in decreasing the soluble Cl^- was most marked in the sand soil, where C_2, C_3 and C_4 showed 34.66, 20.17 and 57.34 % decrease respectively. In the sandy clay soil, C_2 and C_4 decreases were 22.33 and 13.02 %, respectively.

Soluble Na^+ of soil paste extract "Table 45 of appendix 1 and Fig. 59":

Values of soluble Na^+ were measured at end of experiment. The general trend of soluble Na^+ before start of experiment and its end shows a decrease in soluble Na^+ (compare table 1 with table 45 of Appendix 1).

Only the plastic sheet decreased soluble Na^+ of soil paste extract (average of 8.16 %). Other materials increased it. Decreased soluble Na^+ by mulching was most marked in the sandy clay soil, where C_2 caused 17.74 % decrease. In the sand soil, C_4 showed the least decrease in soluble Na^+ 2.36 %.

Conclusive assessment on results of experiment 5: effect of mulching practice on alleviating salinity stress:

Mulching contributed to alleviating salinity stress, particularly where the mulching material was coarse-sand. The use of straw may have involved microbial decomposition of such material of high C/N ratio. The result of getting very little increase in plant growth using straw may have been due to a net immobilization of soil available N. Coarse sand on the other hand may have decreased evaporation to a marked extend.