RESULTS AND DISCUSSION

4. RESULTS AND DISCUSSION

4.1. Effect of irrigation with diluted sea water on some soil chemical properties:

4.1.1. Soil salinity (EC):

a. After one day of incubation:

Data presented in Table (3) show that increasing salinity of irrigation water corresponding to dilutions of sea water with tap water from 95 % to 60 % of its initial strength caused soil salinity (expressed as EC in dS m^{-1}) to increase from 8.38 to 15.1 dS m^{-1}. This occurred in absence of application of any nutritive element. However, the combined effect of irrigation of the soil together with application of P at a rate of 10 µg g^{-1} caused EC to increase from 8.34 up to 16.48 dS m^{-1} when salinity of the irrigation water was increased.

Substituting the applied P by Zn at a rate of 5 µg g^{-1} was associated with increasing the corresponding EC values from 7.65 to 15.10 dS m^{-1}. When irrigation of the pots was accompanied by application of Mn at a rate of 5 µg g^{-1}, the corresponding EC values increased from 9.81 to 17.07 dS m^{-1}. On the other hand, tap water treatment (control) resulted in the lowest value of soil salinity (EC = 3.17 dS m^{-1}).

Thus, it could be concluded that addition of P, Zn or Mn nutrients to the soil with the above-mentioned dilutions of sea water increased soil salinity in the following descending order: Mn treatments > P treatments > the initial soil treatments > Zn treatments > control treatment (tap water).

Table (3): Some chemical characteristics of the studied soil irrigated with dilutions of sea water under application of P, Zn or Mn (after one day).

Treatments	pH	EC (dS/m)	Soluble anions ($mmol_c/L$)				Soluble cations ($mmol_c/L$)				SAR
			$CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	
Tap water (control)	8.0	3.17	–	1.2	10.0	21.80	7.84	6.16	18.10	0.04	6.79
Sea water 5 %	7.87	8.38	–	1.2	70	14.60	8.39	11.17	66.0	0.24	20.82
Sea water 10 %	7.98	9.84	–	1.2	76	23.36	8.28	16.28	75.0	1.00	21.43
Sea water 20 %	7.78	11.34	–	1.8	98	27.25	9.85	24.90	91.3	1.00	21.89
Sea water 30 %	7.84	13.90	–	2.5	112	52.52	18.0	32.56	113.46	1.00	22.56
Sea water 40 %	7.88	15.10	–	3.0	143	52.30	22.0	44.10	131.2	1.00	22.82
Sea water 5 % + P	8.0	8.34	–	1.2	68	16.80	9.32	14.32	62.0	0.36	18.02
Sea water 10 % + P	7.94	9.79	–	1.2	78	22.64	10.35	17.09	73.4	1.00	19.73
Sea water 20 % + P	7.91	11.14	–	1.2	100	30.54	14.49	22.75	93.0	1.50	21.53
Sea water 30 % + P	7.92	13.55	–	2.0	125	33.34	15.00	23.00	120.84	1.50	27.72
Sea water 40 % + P	7.86	16.48	–	2.0	148	41.12	15.97	30.55	143.0	1.60	29.67
Sea water 5 % + Zn	8.06	7.65	–	1.2	59	19.39	10.02	8.07	60.5	1.00	20.10
Sea water 10 % + Zn	8.04	7.96	–	1.2	62	20.15	10.53	8.82	63.0	1.00	20.26
Sea water 20 % + Zn	7.93	9.46	–	1.2	76	22.86	10.85	14.21	74.0	1.00	20.90
Sea water 30 % + Zn	7.84	12.23	–	1.2	105	30.58	10.35	29.93	95.25	1.50	21.21
Sea water 40 % + Zn	7.87	15.10	–	2.0	130	46.18	17.00	39.00	120.93	1.25	22.86
Sea water 5 % + Mn	7.89	9.81	–	1.2	80	20.58	12.42	13.06	75.3	1.00	21.09
Sea water 10 % + Mn	7.85	11.20	–	2.0	88	28.98	12.02	18.16	87.0	1.00	22.42
Sea water 20 % + Mn	7.81	11.41	–	1.2	99	29.74	10.10	17.09	101.5	1.25	27.51
Sea water 30 % + Mn	7.84	13.94	–	1.2	132	29.82	13.46	22.80	125.5	1.26	29.34
Sea water 40 % + Mn	7.78	17.07	–	2.0	162	48.66	20.00	30.00	161.40	1.00	32.28

b. After 21 days of incubation:

Data presented in Table (4) show that irrigation with the same above-mentioned dilutions of sea water in absence of application of P, Zn or Mn increased soil salinity (EC) from 9.30 to 17.46 dS m^{-1}. The corresponding EC values achieved due to the irrigation with the same dilutions of the sea water in presence of applied P at the rate of 10 µg g^{-1} increased from 7.18 to 13.57 dS m^{-1} whereas those attained due to the same irrigation treatments but in presence of Zn at a rate of 5 µg g^{-1} instead of P ranged from 9.65 to 19.82 dS m^{-1}.

Likewise, EC values increased due to the same irrigation treatments from 10.51 to 16.62 dS m^{-1} when Mn was applied at a rate of 5 µg g^{-1}. On the other hand, tap water treatment (control) resulted in the lowest value of soil salinity (EC = 3.85 dS m^{-1}). Therefore, it could be concluded that addition of P, Zn or Mn nutrients to the soil with the above-mentioned dilutions of sea water after 21 days of incubation increased soil salinity in the following descending order: Mn treatments > Zn treatments > initial soil treatments > P treatments > control treatment (tap water). This may be due to the associated anion $SO_4^{=}$ is more effective than PO_4^{-3} in the decrease of soil salinity.

c. After 42 days of incubation:

Table (5) show that irrigation with the same aforementioned dilutions of sea water caused soil salinity (EC) to increase from 12.10 to 21.00 dS m^{-1} when the irrigated soil did not receive P, Zn or Mn, however, when P was applied at the rate of 10 µg g^{-1} the same dilutions of the sea water caused EC value

Table (4): Some chemical characteristics of the studied soil irrigated with dilutions of sea water under application of P, Zn or Mn (after 21 days).

Treatments	pH	EC (dS/m)	Soluble anions ($mmol_c/L$)				Soluble cations ($mmol_c/L$)				SAR
			$CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	
Tap water (control)	7.84	3.85	–	1.2	10	28.84	7.98	7.75	24.25	0.06	8.66
Sea water 5 %	8.03	9.30	–	2.0	63	29.02	13.50	8.02	72.00	0.5	21.95
Sea water 10 %	7.97	10.09	–	2.0	70	29.58	15.03	8.55	77.00	1.0	22.45
Sea water 20 %	7.83	12.48	–	2.0	100	44.65	18.00	24.20	103.45	1.0	22.54
Sea water 30 %	7.76	15.97	–	2.0	123	57.06	20.00	32.00	129.06	1.0	25.31
Sea water 40 %	7.78	17.46	–	2.0	157	69.41	35.00	34.00	158.41	1.0	26.99
Sea water 5 % + P	8.06	7.18	–	2.0	53	19.50	10.00	10.00	53.50	1.0	16.93
Sea water 10 % + P	7.97	8.15	–	2.0	62	20.29	10.70	11.39	61.00	1.2	18.37
Sea water 20 % + P	7.89	10.68	–	2.0	83	26.82	11.82	16.50	82.00	1.5	21.81
Sea water 30 % + P	7.88	10.98	–	2.0	88	28.18	12.02	18.16	86.00	2.0	22.16
Sea water 40 % + P	7.97	13.57	–	2.0	110	41.51	14.02	23.99	115.00	0.5	26.38
Sea water 5 % + Zn	8.08	9.65	–	1.2	72	26.04	11.21	21.55	66.00	0.48	16.30
Sea water 10 % + Zn	8.07	10.10	–	1.2	66	35.36	12.02	22.04	68.00	0.50	16.46
Sea water 20 % + Zn	7.93	12.58	–	2.0	97	41.00	14.00	20.20	105.00	0.80	25.36
Sea water 30 % + Zn	7.89	18.06	–	2.0	196	15.22	16.06	46.16	150.00	1.00	26.88
Sea water 40 % + Zn	7.89	19.82	–	2.0	218	18.03	22.70	45.83	168.00	1.50	28.72
Sea water 5 % + Mn	7.99	10.51	–	1.2	83	29.82	10.02	16.50	87.00	0.50	23.90
Sea water 10 % + Mn	8.12	11.96	–	1.2	118	31.13	10.35	17.93	91.55	0.50	24.35
Sea water 20 % + Mn	7.94	12.35	–	2.0	95	35.68	12.02	18.16	102.00	0.50	26.29
Sea water 30 % + Mn	7.95	13.87	–	2.0	110	36.01	12.02	22.99	112.00	1.00	26.79
Sea water 40 % + Mn	7.88	16.62	–	2.0	174	38.40	16.00	42.40	164.00	2.00	33.33

Table (5): Some chemical characteristics of the studied soil irrigated with dilutions of sea water under application of P, Zn or Mn (after 42 days).

Treatments	pH	EC (dS/m)	Soluble anions (mmole/L)				Soluble cations (mmole/L)				SAR
			$CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	
Tap water (control)	7.74	3.90	–	1.2	18.0	21.36	8.08	7.84	24.64	0.1	8.74
Sea water 5 %	7.90	12.10	–	2.0	116.0	21.58	17.0	26.00	96.08	0.5	20.71
Sea water 10 %	7.87	15.61	–	3.0	135.0	54.2	28.0	32.7	131.00	0.5	23.77
Sea water 20 %	7.80	16.63	–	3.0	186	25.4	30.0	40.4	142.0	2.0	23.95
Sea water 30 %	7.80	19.46	–	3.0	190	35.68	31.7	44.98	150.0	2.0	24.23
Sea water 40 %	7.72	21.00	–	3.0	244	57.70	38.0	68.00	195.4	3.3	26.84
Sea water 5 % + P	7.97	10.73	–	2.0	83	29.02	10.02	18.50	84.5	1.0	22.35
Sea water 10 % + P	7.88	10.75	–	2.0	86	30.58	10.82	18.56	88.2	1.0	23.03
Sea water 20 % + P	7.84	11.21	–	2.0	88	31.18	10.88	18.80	90.5	1.0	23.51
Sea water 30 % + P	7.54	12.72	–	2.0	103	33.95	14.00	19.95	104.0	1.0	25.24
Sea water 40 % + P	7.38	20.77	–	2.0	162	81.87	18.04	43.83	183.0	1.0	32.68
Sea water 5 % + Zn	8.09	10.12	–	1.5	66	36.56	12.02	22.04	69.5	0.5	16.83
Sea water 10 % + Zn	8.15	10.42	–	1.5	76	40.49	14.35	25.09	78.05	0.5	17.58
Sea water 20 % + Zn	8.08	12.88	–	1.5	98	57.20	24.00	34.70	97.0	1.0	17.90
Sea water 30 % + Zn	8.04	13.02	–	1.5	100	58.69	25.39	35.02	98.48	1.3	17.91
Sea water 40 % + Zn	8.03	14.45	–	2.0	122	60.97	26.00	39.47	118.0	1.5	20.63
Sea water 5 % + Mn	8.17	8.92	–	1.5	66	24.48	9.32	20.08	62.0	0.28	16.19
Sea water 10 % + Mn	8.12	9.04	–	1.5	72	25.36	10.28	17.28	69.5	0.5	18.73
Sea water 20 % + Mn	7.83	12.16	–	2.0	95	35.68	12.02	18.16	102.0	0.5	26.29
Sea water 30 % + Mn	7.78	13.82	–	2.0	110	41.51	12.02	20.99	120.0	0.5	29.56
Sea water 40 % + Mn	7.80	13.99	–	2.0	114	44.2	12.02	21.93	125.25	1.0	30.40

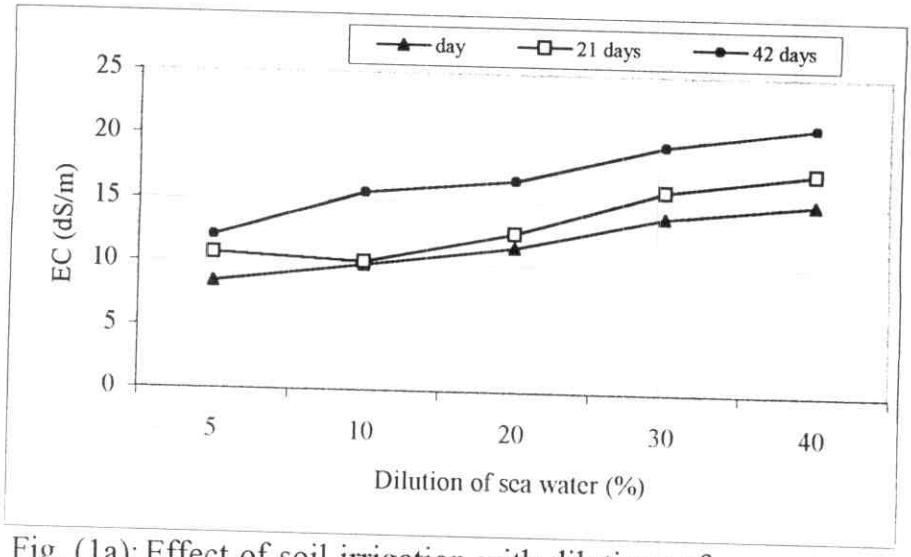


Fig. (1a): Effect of soil irrigation with dilutions of sea water on EC through periods of incubation.

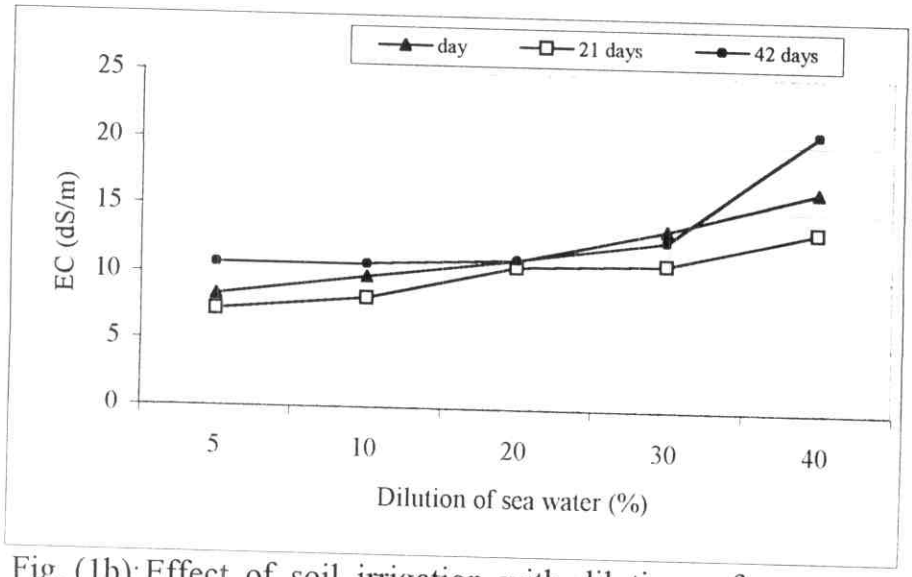


Fig. (1b): Effect of soil irrigation with dilutions of sea water under application of P on EC through periods of incubation.

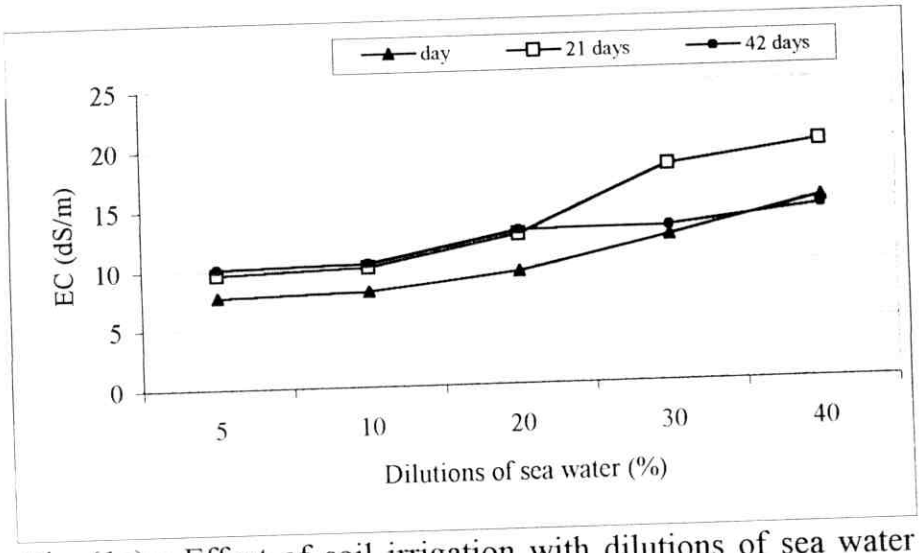


Fig. (1c):: Effect of soil irrigation with dilutions of sea water under application of Zn on EC through periods of incubation.

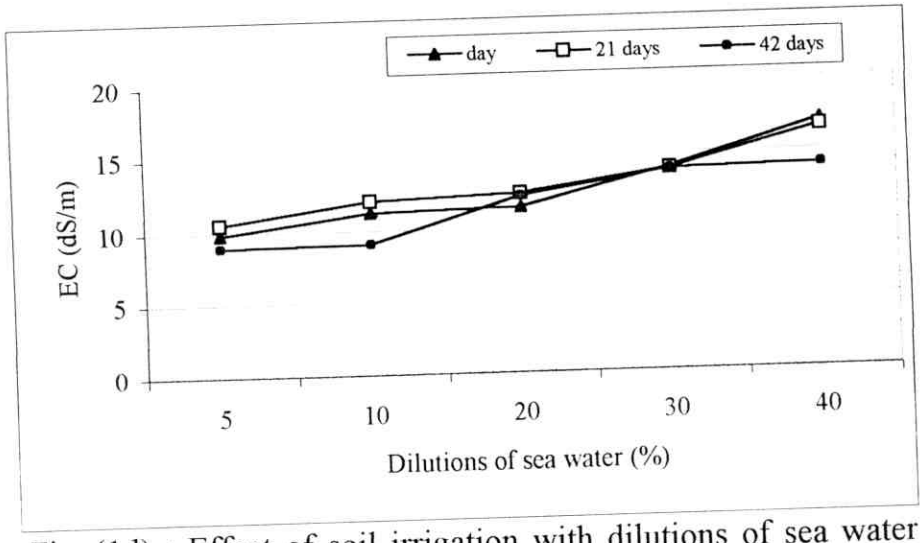


Fig. (1d):: Effect of soil irrigation with dilutions of sea water under application of Mn on EC through periods of incubation.

to increase from 10.73 to 20.77 dS m^{-1}. Substituting P by Zn at a rate of 5 µg g^{-1} under the same irrigation treatments caused EC value to increase from 10.12 to 14.45 dS m^{-1}. The same irrigation treatments in presence of Mn at a rate of 5 µg g^{-1} caused EC value to increase from 8.92 to 13.99 dS m^{-1}. The tap water treatment resulted in the lowest value of soil salinity (3.90 dS m^{-1}).

Therefore, addition of P, Zn or Mn nutrients to the soil with the above-mentioned dilutions of sea water after 42 days of incubation increased soil salinity in the following descending order: the initial soil treatments > P treatments > Zn treatments > Mn treatments > control treatment (tap water).

From the above-mentioned results, it could be concluded that the best treatment which gave the lowest EC value was irrigation by tap water (control) followed by 5 % of sea water dilution with Zn treatment (5 µg g^{-1}) after one day of incubation or with P treatment (10 µg g^{-1}) after 21 days of incubation or with Mn treatment (5 µg g^{-1}) after 42 days of incubation.

4.1.2. Soluble anions and cations in the soil:

Data presented in Tables (3, 4 and 5) show that using water dilutions as 0, 5, 10, 20, 30 and 40 % of the initial sea water strength for soil irrigation increased both soluble anions and cations in the soil as follows: bicarbonate ions from 1.2 to 3.0 $mmol_c/L$, chloride ions from 10 to 143.0 $mmol_c/L$, sulfate ions from 21.80 to 52.30 $mmol_c/L$, calcium ions from 7.84 to 22.0 $mmol_c/L$, magnesium ions from 6.16 to 44.10 $mmol_c/L$,

sodium ions from 18.10 to 131.2 $mmol_c/L$ and potassium ions from 0.04 to 1.00 $mmol_c/L$.

The distribution of soluble anions showed that the dominant anion was Cl^- followed by $SO_4^=$ and then HCO_3^-. The distribution of soluble cations showed that the dominant cation was Na^+ followed by Mg^{++} then Ca^{++} and finally K^+.

Addition of P at the rate of 10 $\mu g\ g^{-1}$ with the above-mentioned dilutions of sea water increased soluble ions as follows: bicarbonate ions (HCO_3^-) from 1.2 to 2.0 $mmol_c/L$, chloride ions (Cl^-) from 68.0 to 148.0 $mmol_c/L$, sulphate ions ($SO_4^=$) from 16.8 to 41.12 $mmol_c/L$, calcium ions (Ca^{++}) from 9.32 to 15.97 $mmol_c/L$, magnesium ions (Mg^{++}) from 14.32 to 3.55 $mmol_c/L$, sodium ions (Na^+) from 62.0 to 143.0 $mmol_c/L$ and potassium ions (K^+) from 0.36 to 1.60 $mmol_c/L$.

Addition of Zn at the rate of 5 $\mu g\ g^{-1}$ with the same aforementioned dilutions of sea water increased soluble ions as follows: bicarbonate ions (HCO_3^-) from 1.2 to 2.0 $mmol_c/L$, chloride ions (Cl^-) from 59.0 to 130.0 $mmol_c/L$, sulphate ions ($SO_4^=$) from 19.39 to 46.18 $mmol_c/L$, calcium ions (Ca^{++}) from 10.02 to 17.00 $mmol_c/L$, magnesium ions (Mg^{++}) from 8.07 to 39.00 $mmol_c/L$, sodium ions (Na^+) from 60.5 to 120.93 $mmol_c/L$ and potassium ions (K^+) from 1.0 to 1.25 $mmol_c/L$.

Addition of Mn at the rate of 5 $\mu g\ g^{-1}$ with the same above-mentioned dilutions of sea water increased soluble ions as follows: HCO_3^- from 1.2 to 2.0 $mmol_c/L$, Cl^- from 80.0 to 162.0 $mmol_c/L$, $SO_4^=$ from 20.58 to 48.66 $mmol_c/L$, Ca^{++} from 12.42 to

20.00 $mmol_c/L$, Mg^{++} from 13.06 to 30.00 $mmol_c/L$, Na^{+} from 75.3 to 161.40 $mmol_c/L$, and K^{+} from 1.00 to 1.26 $mmol_c/L$.

The distribution of soluble anions showed that the dominant anion was Cl^{-} followed by $SO_4^{=}$ and then HCO_3^{-}. The distribution of soluble cations showed that the dominant cation was Na^{+} followed by Mg^{++}, Ca^{++} and then K^{+}. These results agree with those reported by **U.S. Salinity Lab. Staff 1969** who recorded that the principal soluble anions present in saline and saline alkali soils are chloride and sulphate, the bicarbonate content is relatively low and carbonate is absent. The soluble sodium contents exceed those of calcium plus magnesium somewhat.

As for the effect of incubation periods of soil treated with dilutions of sea water (without or with P, Zn or Mn), data presented in Tables (3, 4 and 5) indicated that the distributions of soluble anions and cations were as follows: the dominant anion was Cl^{-} followed by $SO_4^{=}$ and then HCO_3^{-}, and the dominant cation was Na^{+} followed by Mg^{++}, Ca^{++} and then K^{+}. These results agree with those reported by **U.S. Salinity Lab. Staff 1969** and coincide, to a great content, with the ionic composition of the sea water (Table 2) which illustrates the dominance of Na^{+} followed by Mg^{++} over Ca^{++} which K^{+} was of the least abundance cation and reveals that the anionic composition was dominated by Cl^{-} then $SO_4^{=}$ followed by HCO_3^{-} whereas $CO_3^{=}$ anions were hardly detected.

4.1.3. Sodium adsorption ratio (SAR):

Data presented in Table (3) show that increasing salinity of the irrigation water by using the dilutions of sea water under study increased sodium adsorption ratio (SAR) of the studied soil (after one day) from 20.82 to 22.82 when no application of P, Zn or Mg occurred, however, upon application of P at the rate of 10 $\mu g\ g^{-1}$ the corresponding SAR values increased from 18.02 to 29.67. Substituting P by Zn at the rate of 5 $\mu g\ g^{-1}$ caused SAR values to increase from 20.10 to 22.86 whereas introducing Mn instead of Zn at the same rate caused SAR values to increase from 21.09 to 32.28. On the other hand, tap water treatment (control) resulted in the lowest value of soil SAR (6.79 $dS\ m^{-1}$).

So, addition of P, Zn or Mn nutrients to the soil with the above-mentioned dilutions of sea water increased SAR values of the soil treatments in the descending order: Mn treatments > the initial soil treatments > Zn treatments > P treatments > tap water treatment (control).

After 21 days of incubation, data presented in Table (4) show that irrigation with the different dilutions of the sea water i.e., 5, 10, 20 and 30 % of its initial strength increased soil SAR values as follows: 21.95, 22.45, 22.54, 25.31 and 26.99, respectively for the initial soil which did not receive P, Zn or Mn; 16.93, 18.37, 21.81, 22.16 and 26.38, respectively for the soil that received P at the rate of 10 $\mu g\ g^{-1}$; 16.30, 16.46, 25.36, 26.88 and 28.72, respectively for the soil that received Zn at the rate of 5 $\mu g\ g^{-1}$; and 23.90, 24.35, 26.29, 26.79 and 33.33, respectively for the soil that received Mn at the rate of 5 $\mu g\ g^{-1}$.

While, tap water treatment (control) gave the lowest value of soil SAR (8.66).

So, addition of P, Mn or Zn nutrients to the soil with the above-mentioned dilutions of sea water after 21 days of incubation increased soil SAR values in the descending order: Mn treatments > the initial soil treatments > Zn treatments > P treatments > tap water treatment (control).

After 42 days of incubation, data presented in Table (5) show that irrigation with the same above-mentioned dilutions of sea water increased soil SAR as follows: 20.71, 23.77, 23.95, 24.23 and 26.84, respectively for the initial soil; 22.35, 23.03, 23.51, 25.24 and 32.68, respectively for the soil upon application of P at the rate of 10 µg g^{-1}; 16.83, 17.58, 17.90, 17.91 and 20.63, respectively for the soil upon application of Zn at the rate of 5 µg g^{-1}; and 16.19, 18.73, 26.29, 29.56 and 30.40, respectively for soil upon application of Mn at the rate of 5 µg g^{-1}. While, tap water treatment gave the lowest value of soil SAR (8.74).

So, addition of P, Mn or Zn nutrients to the soil with the above-mentioned dilutions of sea water after 42 days of incubation increased soil SAR values in the descending order: P treatments > Mn treatments > the initial soil treatments > Zn treatments > tap water treatment (control).

From the above-mentioned results, it could be concluded that the best treatment, which gave the lowest SAR value was irrigation by tap water (control) whereas irrigation with dilutions of sea water treatments raised SAR values several times. So, the

soil became sodic soil according to **U.S. Salinity Lab. Staff 1969**. The best sea water dilution treatment which gave the lowest SAR value was 5 % of its initial strength with P treatment (10 μg g^{-1}) after one day of incubation or with Zn treatment (5 μg g^{-1}) after 21 and 42 days of incubation.

Afifi et al. 1998 found that frequent alternation of saline and fresh water at ratio 1: 1 caused considerable attenuation of salinity build-up, especially in sandy soils. SAR of soil solution and hence the potential sodicity hazard was appreciably high, indicating that the use of diluted sea water for irrigation appears to be limited except in case of adopting practices able to counteract soil sodication.

4.1.4. Soil reaction (pH):

a. After one day of incubation:

Data presented in Table (3) show that using dilutions of the sea water corresponding to 5, 10, 20, 30 and 40 % of its initial strength for irrigating the studied soil caused its pH value to decrease from 8.0 to 7.87, 7.98, 7.78, 7.84 and 7.88, respectively. Addition of P at the rate of 10 μg g^{-1} to the soil under the same irrigation treatments decreased pH values from 8.0 to 7.94, 7.91, 7.92 and 7.86, respectively. Addition of Zn at the rate of 5 μg g^{-1} instead of P under the same irrigation treatments changed pH values from 8.0 to 8.60, 8.04, 7.93, 7.84 and 7.87, respectively.

Substituting Zn by Mn at the rate of 5 μg g^{-1} under the same irrigation treatments decreased pH values from 8.0 to 7.89, 7.85, 7.81, 7.84 and 7.78, respectively.

b. After 21 days of incubation:

Data presented in Table (4) show that soil irrigation with the same levels of sea water dilutions changed soil pH values from 7.84 to 8.03, 7.97, 7.83, 7.76 and 7.78, respectively.

Addition of P at the rate of 10 $\mu g\ g^{-1}$ with the same levels of sea water dilutions changed soil pH values from 7.84 to 8.06, 7.97, 7.89, 7.88 and 7.97, respectively.

Addition of Zn at the rate of 5 $\mu g\ g^{-1}$ with the same levels of sea water dilutions changed soil pH values from 7.84 to 8.08, 8.07, 7.93, 7.89 and 7.89, respectively.

Addition of Mn at the rate of 5 $\mu g\ g^{-1}$ with dilutions of 5 and 10 % of the sea water strength increased pH values to 7.99 and 8.12, respectively, then, it decreased to 7.94, 7.95 and 7.88 upon application of the dilutions 20, 30 and 40 % of sea water strength, respectively.

c. After 42 days of incubation:

Data presented in Table (5) show that soil irrigation with the same dilutions of the sea water increased soil pH values from 7.74 (control) to 7.90 upon irrigation with dilution 5 % of sea water strength, then, it decreased to 7.87, 7.80, 7.80 and 7.72 upon applications of the dilutions corresponding to 10, 20, 30 and 40 % of sea water strength, respectively.

Addition of P at the rate of 10 $\mu g\ g^{-1}$ under the same irrigation treatments resulted in pH values of 7.97, 7.88, 7.84, 7.54 and 7.38, respectively.

Addition of Zn at the rate of 5 µg g^{-1} with 5 and 10 % dilutions of sea water strength increased soil pH value to 8.09 and 8.15, respectively. Then, it decreased slightly to 8.08, 8.04 and 8.03 upon application of the dilutions 20, 30 and 40 % of sea water strength, respectively.

Addition of Mn at the rate of 5 µg g^{-1} with the same levels of sea water dilutions resulted in soil pH values of 8.17, 8.12, 7.83, 7.78 and 7.80, respectively.

From the above-mentioned results, it could be concluded that soil pH, generally, decreases as a result of increasing salinity of the applied irrigation water. This finding agree well with those reported by **Noufal 2000**.

4.2. Availability of some nutrients in the soil as affected by salinity of irrigation water:

4.2.1. Phosphorus (P):

Data presented in Table (6) show that increasing water salinity used for irrigation through using dilutions corresponding to 5, 10, 20, 30 and 40 % of the sea water strength resulted in values of available P in the initial soil i.e., which did not receive P, Zn or Mn of about 7.73, 7.07, 6.03, 3.67 and 2.40 $\mu g\ g^{-1}$, respectively after one day of incubation. While, available P in the control (tap water treatment) was 7.07 $\mu g\ g^{-1}$.

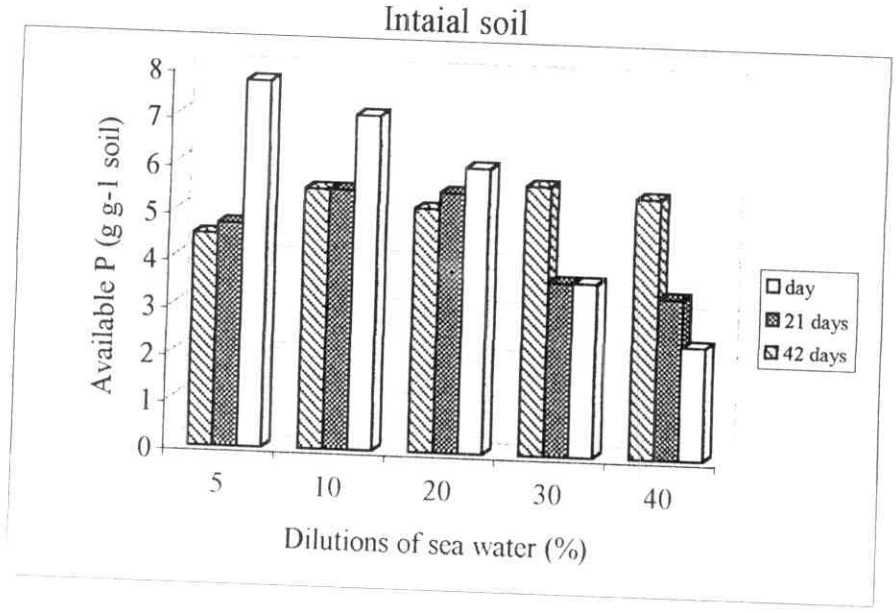
After 21 days of incubation, available P decreased from 4.98 $\mu g\ g^{-1}$ (the control treatment) to 4.72 $\mu g\ g^{-1}$ at 5 % of sea water strength, then it increased to 5.50 and 5.50 $\mu g\ g^{-1}$ at 10 and 20 % of sea water strength, respectively. Therefore, it decreased to 3.67 and 3.40 $\mu g\ g^{-1}$ upon irrigation with dilutions corresponding to 30 and 40 % of sea water strength, respectively. This may be due to phosphorus fixation in the soil.

After 42 days of incubation, available P in the initial soil increased from 4.30 $\mu g\ g^{-1}$ in the control (tap water treatment) to 4.49 and 5.51 $\mu g\ g^{-1}$ upon irrigation with dilutions corresponding to 5 and 10 % of sea water strength, respectively, then, it decreased to 5.16 $\mu g\ g^{-1}$ upon irrigation with a dilutions corresponding to 20 % of sea water strength. Available P increased to 5.70 and 5.50 $\mu g\ g^{-1}$ upon utilization of dilutions corresponding to 30 and 40 % of sea water strength, respectively. This may be due to phosphorus applied to the soil within the irrigation water.

Table (6): Available P in the soil as affected by irrigation with dilutions of sea water.

Treatment	Available P ($\mu g\ g^{-1}$ soil)							
	Incubation periods						Average	
	One day		3 weeks		6 weeks			
	Initial soil	Soil + P	Initial soil	Soil + P	Initial soil	Soil + P	Initial soil	Soil + P
Tap water (control)	7.07		4.98		4.30		5.45	
5 % of sea water	7.73	8.39	4.72	7.47	4.49	9.69	5.65	8.52
10 % of sea water	7.07	8.91	5.50	7.98	5.51	6.81	6.03	7.90
20 % of sea water	6.03	8.58	5.50	6.68	5.16	6.29	5.56	6.70
30 % of sea water	3.67	4.85	3.67	6.68	5.70	4.85	4.35	5.94
40 % of sea water	2.40	3.80	3.40	3.54	5.50	4.53	3.77	3.96
Average	5.38	6.91	4.56	6.47	5.27	6.43	5.07	6.60

Each value is a mean of three replicates.



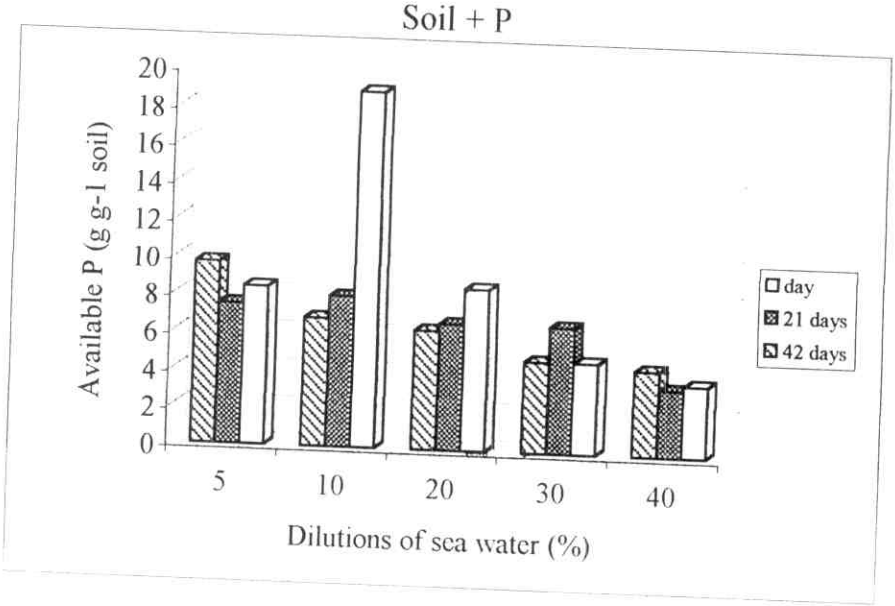


Fig. (2): Effect of irrigation with dilutions of sea water on available-P.

Addition of P at the rate of 10 μg g^{-1} with the above-mentioned levels of sea water dilutions increased available P to 8.39 and 8.91 μg g^{-1} when the soil was irrigated with the dilutions corresponding to 5 and 10 % of sea water strength, respectively, then, it decreased to 8.58, 4.85 and 3.80 μg g^{-1} when salinity of the irrigation water was raised to 20, 30 and 40 % of sea water strength, respectively after on day of incubation.

After 21 days of incubation, available P increased to 7.47 and 7.98 μg g^{-1} upon utilization of the dilutions corresponding to 5 and 10 % of sea water strength, then it decreased to 6.68, 6.68 and 3.54 μg g^{-1} when salinity of the irrigation water was raised to 20, 30 and 40 % of sea water strength, respectively.

After 42 days of incubation, available P content increased to 9.69 when salinity of irrigation water was only 5 % of the sea water strength, then it decreased to 6.81, 6.29, 4.85 and 4.53 μg P g^{-1}soil due to irrigation with dilutions corresponding to 10, 20, 30 and 40 % of sea water strength, respectively.

From the average of all the incubation periods, it could be concluded that using water corresponding to dilutions of 5 and 10 % of the sea water strength for irrigation increased average values of available P from 5.45 μg g^{-1} in the control (tap water treatment) to 5.65 and 6.03 μg g^{-1} in initial soil, and 8.52 and 7.90 μg g^{-1} in the soil + P (10 μg g^{-1}), respectively. However, using dilutions corresponding to 20, 30 and 40 % of the sea water strength caused average values of available P of all the incubation periods to decrease to 5.56, 4.35 and 3.77 μg g^{-1} in

the initial soil and 6.70, 5.94 and 3.96 μg g^{-1} in the soil + P (10 μg g^{-1}), respectively.

These results agree well with those of **Noufal 2000**, who showed that P concentration in the clay soil increased with increasing salinity up to 6 dS m^{-1} beyond which it decreased.

4.2.2. Manganese (Mn):

Data presented in Table (7) show that irrigating the initial soil with dilutions corresponding to 5, 10, 20, 30 and 40 % of sea water strength increased available Mn values after one day of incubation to 10.85, 11.20, 11.84, 14.54 and 16.40 μg g^{-1}, respectively where the available Mn content in the control (tap water treatment) was only 5.2 μg g^{-1}.

After 21 days of incubation, available Mn values were as follows: 5.79, 6.53, 6.34, 7.58 and 9.11 μg g^{-1}, respectively while, available Mn values in the control (tap water treatment) was 5.3 μg g^{-1}.

After 42 days of incubation, available Mn values of the initial soil with the above-mentioned levels of sea water dilutions were 4.33, 5.96, 4.68, 5.16 and 3.88 μg g^{-1}, respectively.

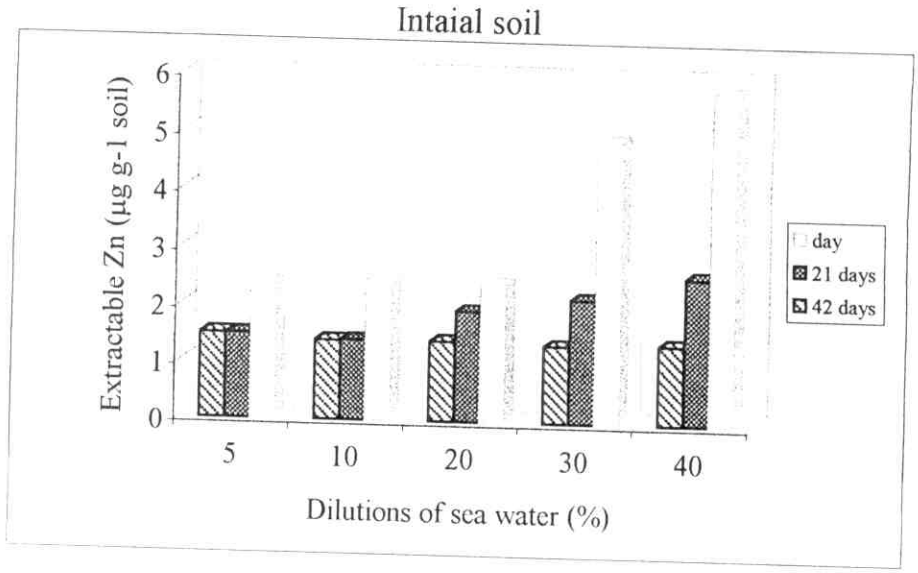
Addition of Mn at the rate of 5 μg g^{-1} with the above-mentioned levels of sea water dilutions increased available Mn to 18.1, 18.4, 18.8, 19.60 and 19.00 μg g^{-1}, respectively.

After 21 days of incubation, available Mn increased due to irrigation by the dilutions 5, 10 and 20 % of sea water strength to 8.81, 9.41 and 9.48 μg g^{-1}, respectively while, it decreased to 8.81 and 8.88 μg g^{-1} due to irrigation by the dilutions

Table (7): AB-DTPA extractable Mn from the soil as affected by irrigation with dilutions of sea water.

Treatments	AB-DTPA extractable Mn ($\mu g\ g^{-1}$ soil)							
	Incubation periods						Average	
	One day		21 days		42 days			
	Initial soil	Soil + Mn	Initial soil	Soil + Mn	Initial soil	Soil + Mn	Initial soil	Soil + Mn
Tap water (control)	5.20		5.30		5.56		5.35	
5 % of sea water	10.85	18.1	5.79	8.81	4.33	6.26	6.99	11.06
10 % of sea water	11.20	18.4	6.53	9.41	5.96	6.95	7.90	11.59
20 % of sea water	11.84	18.8	6.34	9.48	4.68	6.01	7.62	11.43
30 % of sea water	14.54	19.6	7.58	8.81	5.16	5.37	9.43	11.26
40 % of sea water	16.40	19.0	9.11	8.88	3.88	5.59	9.80	11.16
Average	12.12	18.30	7.07	9.08	4.80	6.04	8.35	11.30

* Each value is a mean of three replicates.



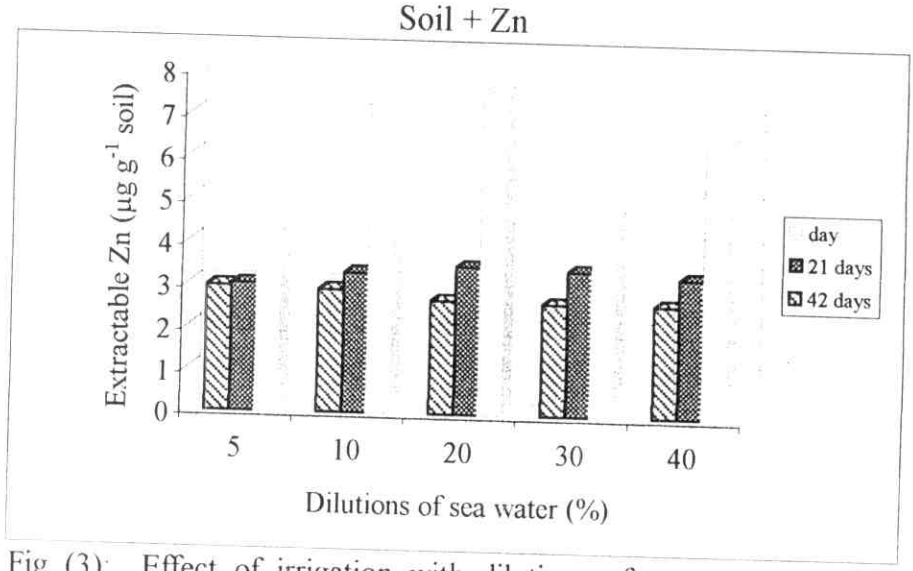


Fig. (3): Effect of irrigation with dilutions of sea water on AB-DTPA extractable Zn.

corresponding to 30 and 40 %, respectively of sea water strength. This may be due to phosphorus fixation in the soil.

After 42 days of incubation, available Mn increased to 6.26 and 6.95 µg g^{-1} due to irrigation by the dilutions corresponding to 5 and 10 %, respectively of sea water strength while, it decreased to 6.01, 5.37 and 5.59 µg g^{-1} due to irrigation by the dilutions corresponding to 20, 30 and 40 %, respectively of sea water dilutions. Similar results were reported by **Noufal 2000**, who showed that increasing salinity decreased Mn concentration in the soil.

4.2.3. Zinc (Zn):

Data presented in Table (8) show that available Zn in the initial soil which did not receive P, Zn or Mn increased from 2.49 µg g^{-1} in the control (tap water treatment) to 2.50 µg g^{-1} due to irrigation with water corresponding to 5 % of sea water strength, then, it decreased to 2.47 and 2.42 µg g^{-1} when the salinity of the applied water was raised to 10 and 20 % of sea water strength, respectively.

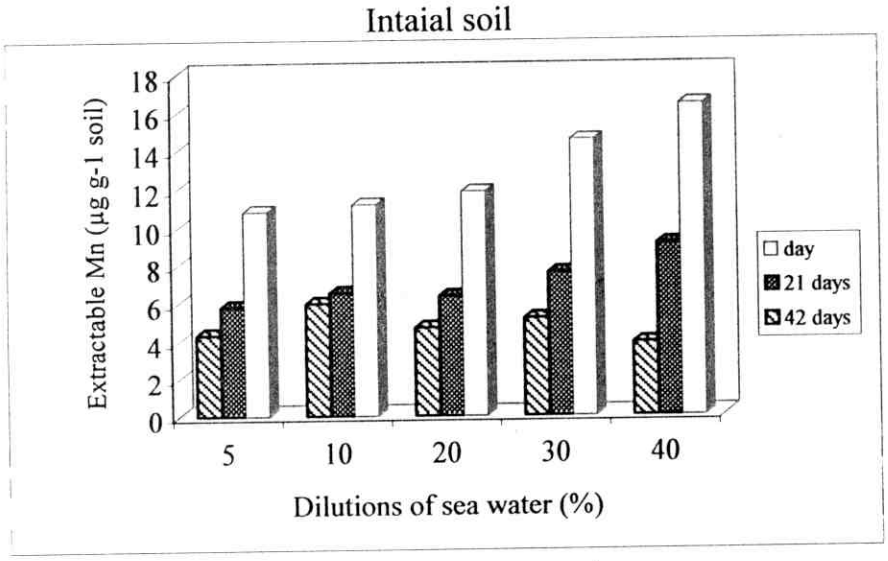
Available Zn increased to 4.91 and 5.79 µg g^{-1} when waters corresponding to the dilutions 30 and 40 %, respectively of sea water strength were used for irrigation.

After 21 days of incubation, available Zn increased from 1.46 in the control (tap water treatment) to 1.49 µg g^{-1} at 5 % of sea water strength while, it decreased to 1.4 µg g^{-1} at 10 % of sea water strength then, it increased once again to 1.93, 2.17 and 2.57 µg g^{-1} at 20, 30 and 40 % of sea water strength, respectively.

Table (8): AB-DTPA extractable Zn from the soil affected by irrigation with dilutions of sea water.

Treatments	AB-DTPA extractable Zn (µg g^{-1} soil)							
	Incubation periods						Average	
	One day		21 days		42 days			
	Initial soil	Soil + Zn	Initial soil	Soil + Zn	Initial soil	Soil + Zn	Initial soil	Soil + Zn
Tap water (control)	2.49		1.46		1.46		1.80	
5 % of sea water	2.50	5.09	1.49	3.01	1.49	2.96	1.83	3.69
10 % of sea water	2.47	7.76	1.40	3.30	1.39	2.90	1.75	4.65
20 % of sea water	2.42	7.62	1.93	3.47	1.40	2.68	1.92	4.59
30 % of sea water	4.91	7.00	2.17	3.42	1.35	2.64	2.81	4.35
40 % of sea water	5.79	6.50	2.57	3.27	1.39	2.64	3.25	4.14
Average	3.62	6.79	1.91	3.29	1.40	2.76	2.31	4.28

* Each value is a mean of three replicates.



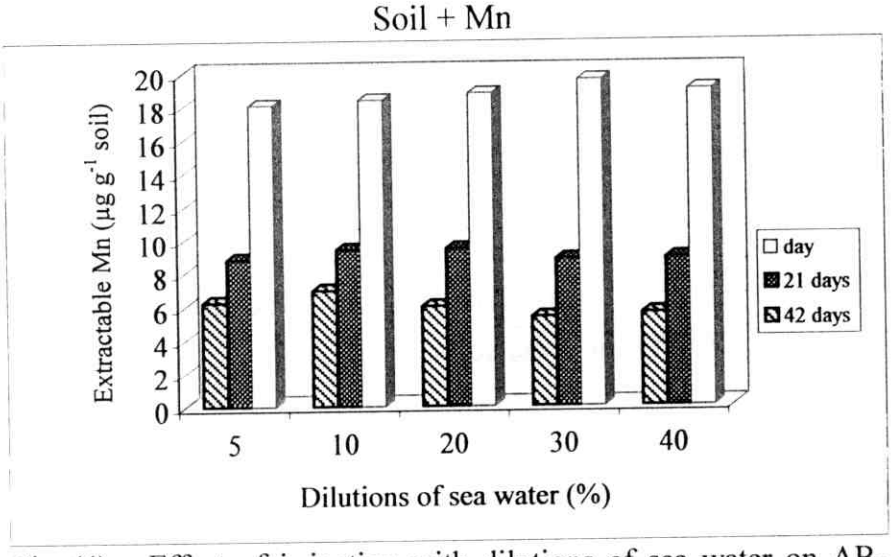


Fig. (4): Effect of irrigation with dilutions of sea water on AB-DTPA extractable Mn.

After 42 days of incubation, available Zn values of the initial soil irrigated with dilutions corresponding to 0, 5, 10, 20, 30 and 40 % of sea water strength were as follows: 1.46, 1.49, 1.39, 1.40, 1.35 and 1.39 $\mu g\ g^{-1}$, respectively.

Addition of Zn at the rate of 5 $\mu g\ g^{-1}$ with the above-mentioned dilutions of sea water increased available Zn after one day of incubation to 5.09 and 7.76 $\mu g\ g^{-1}$ upon application of dilutions corresponding to5 and 10 % of sea water strength. AB-DTPA extractable Zn decreased to 7.62, 7.00 and 6.50 $\mu g\ g^{-1}$ when salinity of the irrigation water was raised to 20, 30 and 40 % of sea water strength, respectively.

After 21 days of incubation, available Zn values decreased to 3.01, 3.30, 3.47, 3.42 and 3.27 $\mu g\ g^{-1}$ under the irrigation treatments corresponding to the dilutions 5, 10, 20, 30 and 40 % of sea water strength, respectively.

After 42 days of incubation, the corresponding values decreased to 2.96, 2.90, 2.68, 2.64 and 2.64 $\mu g\ g^{-1}$, respectively. These results agree, to some extent, with those of **Noufal 2000**, who showed that increasing salinity decreased Zn concentration in the soil. **Singh and Abrol 1985** indicated that Zn solubility at pH higher than 7.9 was controlled by precipitation of Zn as $Zn(OH)_2$ or $ZnCO_3$ in sodic soils.

4.3. Effect of salinity irrigation water on plant growth:

4.3.1. Dry matter yield:

After 45 days of sowing barley plants in the studied soil, data presented in Table (9) show that dry matter yield increased slightly from 3.54 g pot^{-1} (control) to 3.57 g pot^{-1} at 5 % of sea water dilution treatment. While, it decreased insignificantly to 3.40 and decreased significantly to 2.64, 2.44 and 2.29 g pot^{-1} when salinity of the irrigation water was raised to 10, 20, 30 and 40 %, respectively of sea water strength. This may be due to the salt tolerance of barley plants. So, low levels of salinity (EC 3 dS m^{-1} at control treatment and 5.58 dS m^{-1} at 5 % of sea water dilution) enhanced plant dry matter yield then, high levels of salinity decreased dry matter yield. **Lovelli et al. 1997** found that the growth and leaf area of bean (Phaseolus vulgaris) were strongly reduced by salinity due to irrigation with 0.39 dS m^{-1} (tap water, control), 10 and 20 dS m^{-1}. Also, as salinity built up, a significant increase in stomatal resistance was observed which coincided with a reduction in the photosynthetic activity, especially in treatments with the most severe stress.

Addition of P at the rate of 10 µg g^{-1} to the same dilutions of sea water, increased insignificantly dry matter yield to 4.06 and increased significantly to 4.91 g pot^{-1} with the dilutions corresponding to 5 and 10 %, respectively of sea water strength while, it decreased dry matter yield to 3.53, 3.25 and 3.23 g pot^{-1} at 20, 30 and 40 %, respectively of sea water strength. However, these values were higher than those in the initial soil due to the effect of P on increasing dry matter yield.

Table (9): Dry matter yield of barley plant as affected by soil irrigation with different dilutions of sea water under application of P, Zn or Mn (after 45 days from sowing).

Treatments	Dry matter yield of barley plant (DM)							
	Initial soil		Soil + P		Soil + Zn		Soil + Mn	
	g pot^{-1}	RGY %	g pot^{-1}	RGY %	g pot^{-1}	RGY %	g pot^{-1}	RGY %
Tap water (control)	3.54	100	3.92	100	3.68	100	3.51	100
5 % of sea water	3.57	100.8	4.06	103.57	3.49	94.84	3.36	99.96
10 % of sea water	3.40	96.05	4.91	125.26	3.63	98.64	3.30	94.02
20 % of sea water	2.64	74.58	3.53	90.05	3.49	94.84	2.97	84.62
30 % of sea water	2.44	68.93	3.25	82.91	3.26	88.60	2.34	66.67
40 % of sea water	2.29	64.99	3.23	82.40	2.98	80.98	2.37	67.52
Average	2.87	81.07	3.80	96.94	3.37	91.58	2.87	81.77
LSD (0.05):	0.25		0.33		0.10		0.10	

RGY % = Relative growth yield % = $y/y_o \times 100$

* Each value is a mean of three replicates.

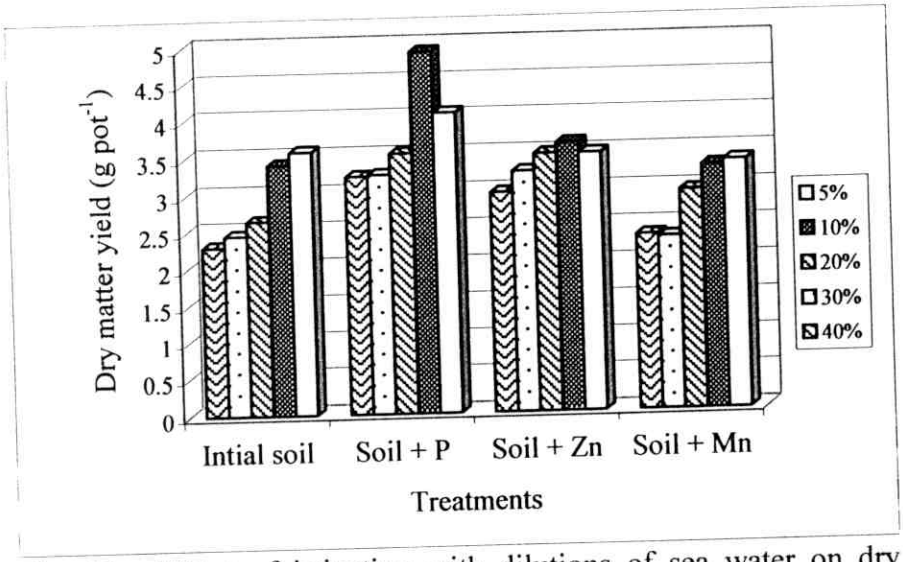


Fig. (5): Effect of irrigation with dilutions of sea water on dry matter yield of barley (after 45 days of sowing).

Addition of Zn at the rate of 5 μg g^{-1} to the same levels of sea water dilutions, decreased significantly the dry matter yield to 3.49 and 3.63 g pot^{-1} at 5 and 10 %, respectively of sea water strength. On the other hand, dry matter yield decreased to 3.49, 3.26 and 2.98 g pot^{-1} at 20, 30 and 40 %, respectively of sea water strength. However, these values were still higher than those of the initial soil treatments.

Addition of Mn at the rate of 5 μg g^{-1}, respectively with the same levels of sea water dilutions decreased significantly dry matter yield to 3.36, 3.30, 2.97, 2.34 and 2.37 g pot^{-1}, respectively. However, these values were higher than those in the initial soil treatment due to the effect of added Mn.

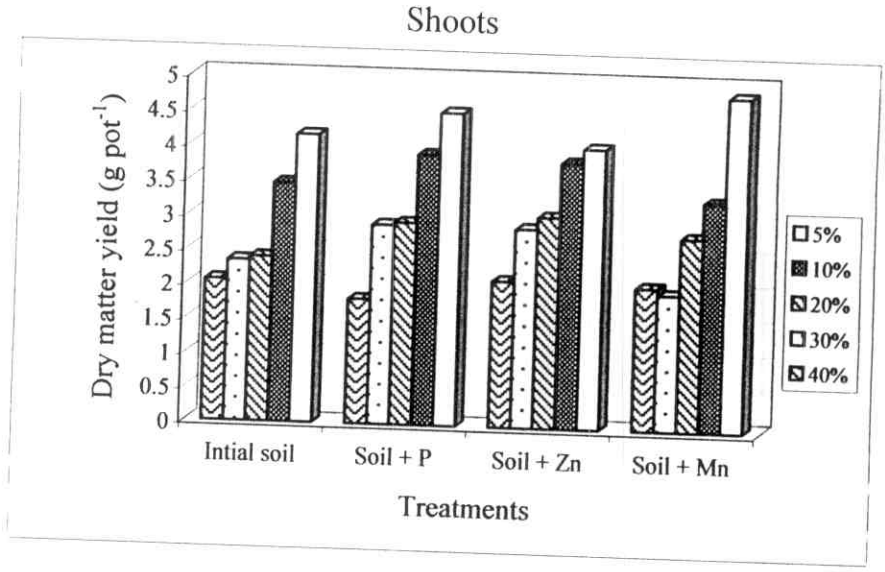
After 90 days of planting, data presented in Table (10) show that the different dilutions of the sea water, except for the first one i.e., 5 % of the sea water strength, used for irrigating the studied soil decreased dry weight of barley shoots. Dry weight of seeds increased significantly from 1.94 to 2.01, 2.07 and 2.04 g pot^{-1} when the soil was irrigated with the dilution corresponding 5, 10 and 20 %, respectively of sea water strength. While, it decreased insignificantly to 1.92 and decreased significantly to 0.93 g pot^{-1} when salinity of the irrigation water was raised to 30 and 40 %, respectively of sea water strength.

Addition of P at the rate of 10 μg g^{-1} with the above-mentioned levels of sea water dilutions although increased significantly the dry weight of shoots when salinity of irrigation water did not exceed 5 % of the sea water strength, yet further significant increase in salinity of the irrigation water to

Table (10): Dry matter yield of barley plant as affected by soil irrigation with different dilutions of sea water under application P, Zn or Mn (after 90 days from sowing).

Treatments	Dry matter yield of barley plant (DM)															
	Initial soil				Soil + P				Soil + Zn				Soil + Mn			
	shoots	seeds	shoots + seed	RGY %	shoots	seeds	shoots + seed	RGY %	shoots	seeds	shoots + seed	RGY %	shoots	seeds	shoots + seed	RGY %
	g pot^{-1}				g pot^{-1}				g pot^{-1}				g pot^{-1}			
Tap water (control)	4.12	1.94	6.06	100	4.72	2.26	6.98	100	4.24	1.86	6.10	100	4.45	1.78	6.23	100
5 % of sea water	4.16	2.01	6.17	101.8	4.52	3.36	7.86	112.6	4.05	1.91	5.96	97.7	4.84	2.62	7.46	119.7
10 % of sea water	3.46	2.07	5.53	91.3	3.91	3.05	6.96	99.71	3.84	1.94	5.78	94.8	3.32	1.92	5.24	84.11
20 % of sea water	2.39	2.04	4.43	73.1	2.93	2.64	5.57	79.80	3.06	1.99	5.05	82.8	2.80	1.64	4.44	71.27
30 % of sea water	2.34	1.92	4.26	70.3	2.89	1.84	4.73	67.77	2.88	1.52	4.40	72.1	1.98	1.07	3.05	48.96
40 % of sea water	2.05	0.93	2.98	49.2	1.81	0.78	2.59	37.11	2.12	1.17	3.29	53.9	2.07	1.44	3.51	56.34
Average	2.88	1.79	4.67	77.1	3.21	2.33	5.54	79.40	3.19	1.71	4.90	80.3	3.00	1.74	4.74	76.08
LSD (0.05):	0.06	0.06			0.12	0.13			0.08	0.10			0.18	0.16		

RGY % = Relative growth yield % = $y/y_o \times 100$



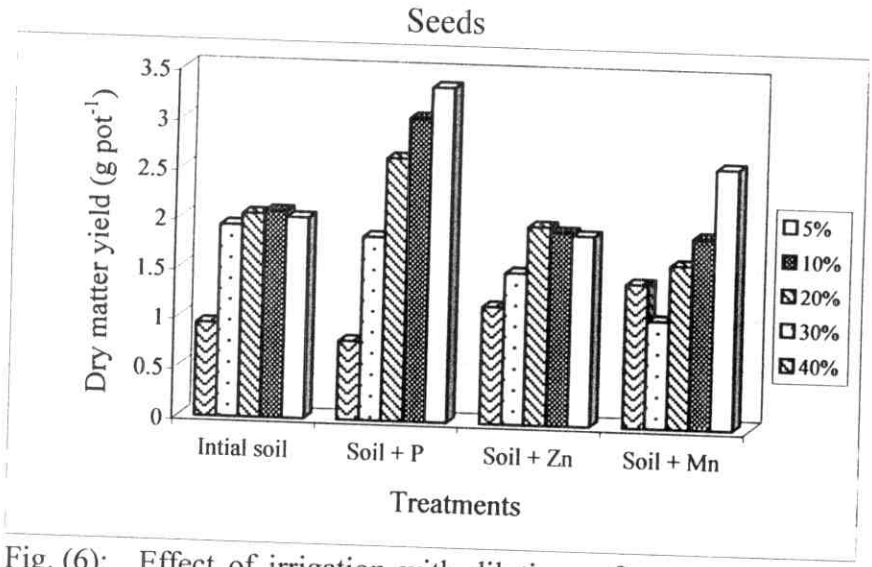


Fig. (6): Effect of irrigation with dilutions of sea water on dry matter yield of barley (after 90 days of sowing).

correspond 10, 20, 30 and 40 % of sea water strength caused the dry matter yield of shoots of 3.91, 2.93, 2.89 and 1.81 g pot^{-1}, respectively. Dry weight of seeds increased significantly to 3.36, 3.05 and 2.64 g pot^{-1} upon irrigation with the dilutions corresponding to 5, 10 and 20 % of the sea water strength, however, increasing salinity of the irrigation water to 30 and 40 % of the sea water strength adversely affected the dry matter yield of seed which was significantly reduced to 1.84 and 0.78 g pot^{-1}, respectively.

Addition of Zn at the rate of 5 µg g^{-1} with the above-mentioned levels of sea water dilutions decreased significantly dry weight of shoots to 4.05, 3.84, 3.06, 2.88 and 2.12 g pot^{-1} at the dilutions of 5, 10, 20, 30 and 40 %, respectively of sea water strength while the dry weight of seeds was insignificantly increased to 1.91 and 1.94; increased significantly to 1.99 then it decreased significantly to 1.52 and 1.17, respectively.

Addition of Mn at the rate of 5 µg g^{-1} with the above-mentioned levels of sea water dilutions, generally, decreased significantly dry weight of shoots to 3.32, 2.80 and 2.07 g pot^{-1} with the dilutions corresponding to 10, 20, 30 and 40 % of sea water strength. An exception was that dry matter yield of shoots increased significantly from 4.45 to 4.84 g pot^{-1} when the soil was irrigating with water dilution corresponding to 5 % of the sea water strength.

Dry weight seeds decreased insignificantly to 1.92 and decreased significantly to 1.64, 1.07 and 1.44 g pot^{-1} when the soil was water with the dilutions corresponding to 10, 20, 30 and

40 % of the sea water strength. Likewise what occurred for shoots, dry matter yield of seeds increased significantly from 1.78 to 2.62 g pot^{-1} due to the irrigation with the water dilution corresponding to 5 % of the sea water strength.

These results agree with the finding reported by **Parakach and Karadge 1980**, who found that salinity is known to retard plant growth through its influence on several factors of plant metabolism like osmotic adjustment, ion uptake, enzyme activities and hormonal balance, and also those obtained by **Sharma 1996**, who found that growth reduction of wheat cultivars differing in salt tolerance caused by salinity was accompanied by increased plant Na^+ and Cl^- concentration, Na^+: K^+ ratio and decreased concentration of K^+.

Similar results were obtained by **Gawish et al 1999, Reda and Amer 1999** and **Noufal 2000**.

4.3.2. Phosphorus in plants:

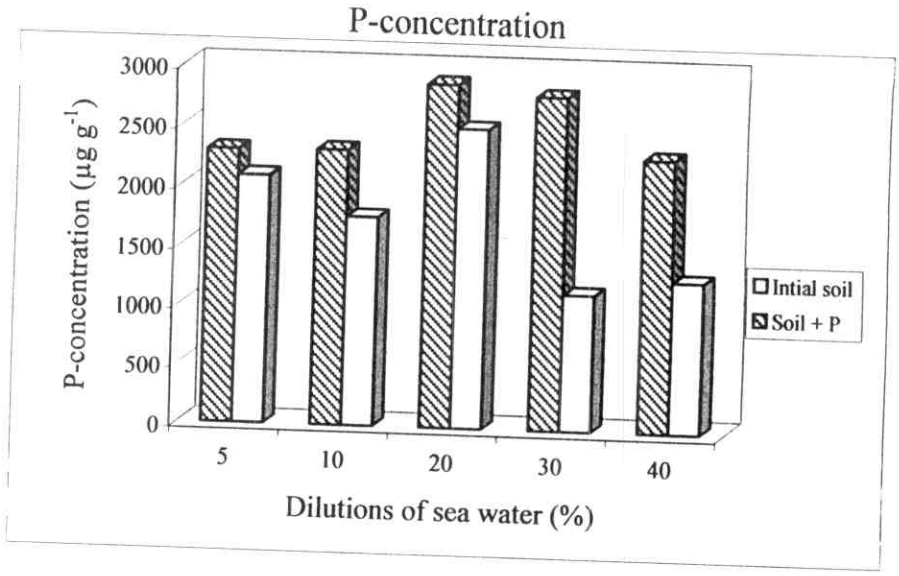
I. Phosphorus concentration:

Data presented in Table (11) show that P concentration in barley shoots after 45 days of sowing decreased significantly due to irrigation with dilutions corresponding to 5, 10, 20, 30 and 40 % of sea water strength from 2.568 (the control treatment) to 2080, 1759, 1509, 1250 and 1274 mg P kg^{-1} plant, respectively. This means that the highest value of P concentration was found in the control treatment (tap water) which was 2568 mg P kg^{-1} plant and the lowest one was attained due to the irrigation with dilution corresponding to 40 % of sea water strength treatment (1274 mg P kg^{-1} plant). Addition of P with the above-mentioned

Table (11): P concentration and uptake by barley plants after 45 days from sowing as affected by soil irrigation with dilutions of sea water.

Treatment	P concentration ($mg\ kg^{-1}$)		P uptake ($mg\ pot^{-1}$)	
	Initial soil	Soil + P	Initial soil	Soil + P
Tap water (control)	2568		9.09	
5 % of sea water	2080	2293	7.43	9.31
10 % of sea water	1759	2306	5.98	11.32
20 % of sea water	1509	2882	3.98	10.17
30 % of sea water	1250	2797	3.05	9.09
40 % of sea water	1274	2286	2.91	7.38
Average	1627	2487	4.67	9.45
LSD (0.05):	119	84	0.15	0.08

* Each value is a mean of three replicates.



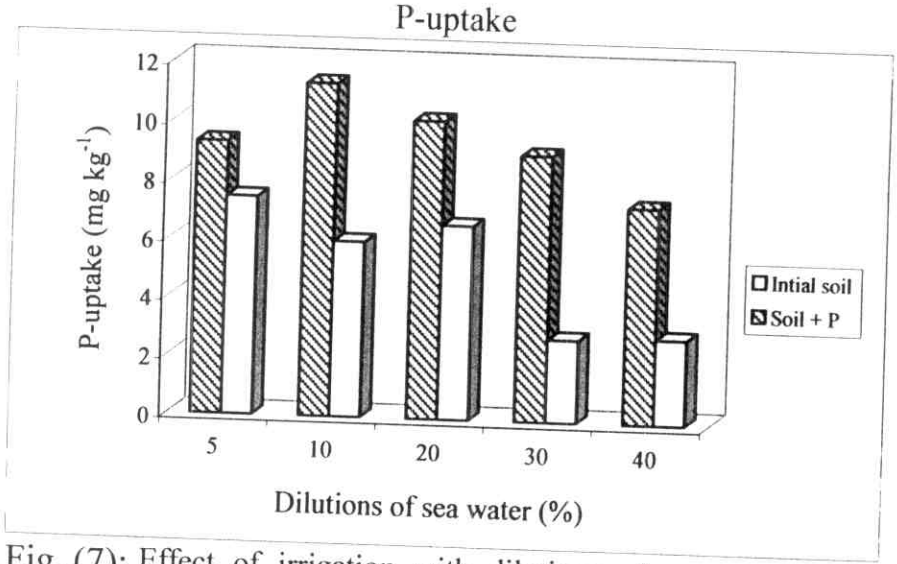


Fig. (7): Effect of irrigation with dilutions of sea water on P concentration and uptake by barley plants (after 45 days of sowing).

dilutions of sea water increased P concentration in plants to values higher than those achieved in the plants grown on the soil which did not receive P.

Concerning P concentration in barley shoots and seeds after 90 days of sowing, data found in Table (12) show that irrigation with the dilutions corresponding to 5, 10, 20 and 30 % of sea water strength increased P concentration in shoots and seeds as compared with the control (tap water) treatment. On the other hand, irrigation with the dilution corresponding to 30 % of the sea water strength caused these values to be slightly lower as compared with the control (tap water) treatment. Addition of P with the above-mentioned dilutions of sea water increased P concentration in plants than those values of the initial soil.

II. Phosphorus uptake by plants:

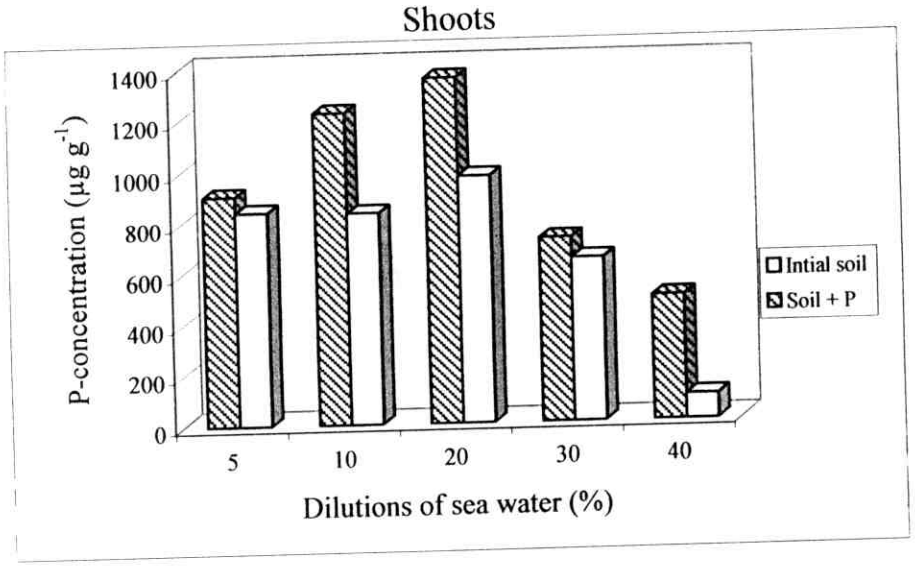
Data presented in Table (11) show that P uptake by barley shoots after 45 days of sowing decreased significantly from 9.09 to 7.43, 5.98, 3.98, 3.05 and 2.91 mg pot^{-1} due to irrigation with the dilutions corresponding to 5, 10, 20, 30 and 40 %, respectively of sea water strength. The aforementioned dilutions when added to the soil in presence of P although showed decreases in uptake values of shoots and seeds in direct proportional relation with level of salinity of the applied water, yet these values remained obviously higher than those attained in absence of P.

After 90 days of sowing barley plants, data presented in Table (12) show that P uptake by plant shoots increased significantly from 1.69 to 3.50, 2.89 and 2.32 mg pot^{-1} at 5, 10

Table (12): P concentration and uptake by barley plants after 90 days from sowing as affected by soil irrigation with dilutions of sea water.

Treatments	P concentration (µg g^{-1} plant)				P uptake (mg pot^{-1} plant)			
	Initial soil		Soil + P		Initial soil		Soil + P	
	Shoots	Seeds	Shoots	Seeds	Shoots	Seeds	Shoots	Seeds
Tap water (control)	409.4	2654.9			1.69	5.15		
5 % of sea water	841.7	2816.5	907.2	2983.8	3.50	5.66	4.10	10.03
10 % of sea water	835.1	2299.1	1224.9	3553.3	2.89	4.76	4.79	10.84
20 % of sea water	972.7	2803.4	1355.9	2888.6	2.32	5.72	3.97	7.63
30 % of sea water	641.9	2390.8	723.8	2420.4	1.50	4.59	2.09	4.45
40 % of sea water	94.97	900.6	491.3	2692.1	0.19	0.84	0.89	2.10
Average	677.27	2242.08	940.62	2907.64	2.08	4.31	3.17	7.01
LSD (0.05):	84	84	60	84	0.25	0.18	0.08	0.19

* Each value is a mean of three replicates.



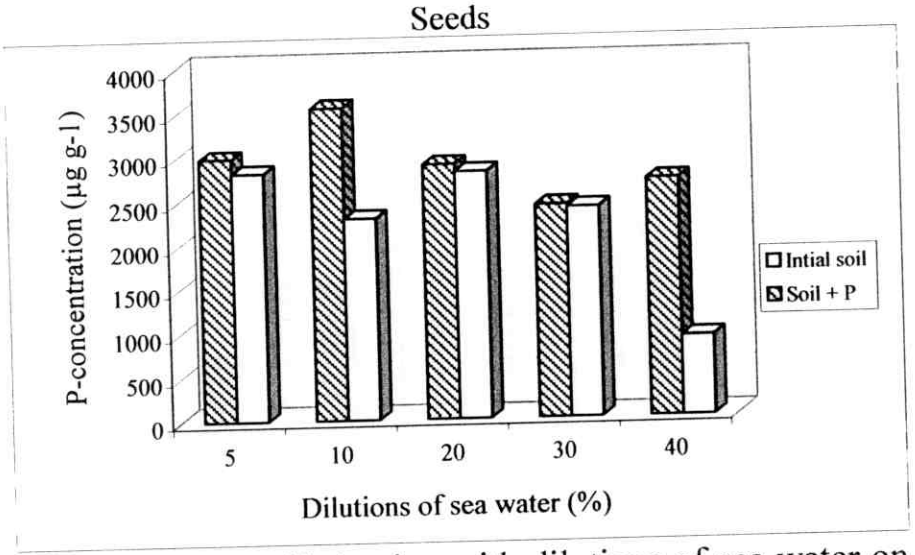
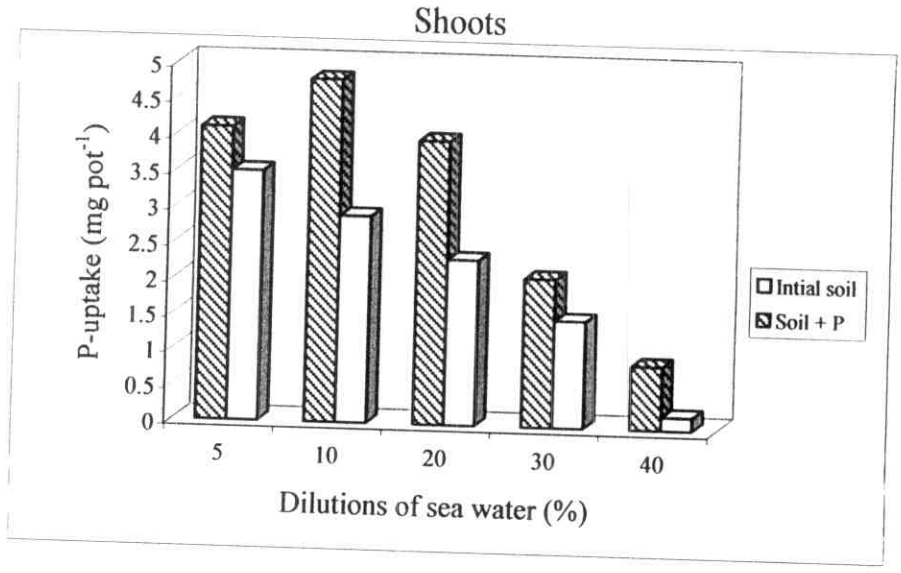


Fig. (8): Effect of irrigation with dilutions of sea water on P concentration in barley plants (after 90 days of sowing).



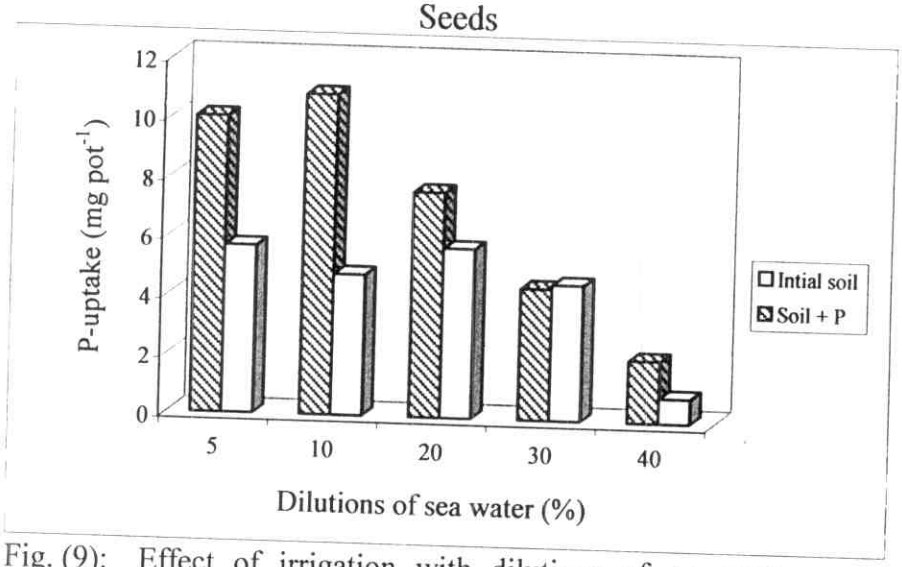


Fig. (9): Effect of irrigation with dilutions of sea water on P uptake by barley plants (after 90 days of sowing).

and 20 %, respectively of sea water strength, then, it decreased insignificantly to 1.50 mg pot^{-1} and decreased significantly to 0.19 mg pot^{-1} when salinity of the irrigation water was raised to 30 and 40 %, respectively of sea water strength. P uptake by seeds followed a trend similar to a great extent to that of P uptake by shoots. In both cases, the highest values of P uptake by plants was found at the rate of 5 % of sea water strength and the lowest one was detected at 40 % of sea water strength. **El-Arquan et al. 1984** found that phosphorus concentration and uptake by broad bean plants are decreased with increasing soil salinity due to the rise of the osmotic pressure of the soil solution. Addition of P with the above-mentioned dilutions of sea water increased P uptake by plants to values higher than those of the initial soil. These results agree with those obtained by **Mass et al. 1979** who found that the increase in P content of barley shoots with increasing water salinity concentration may be attributed to the increasing of plant needs to P for several biological activities. Similar results were obtained by **Wassif et al. 1979.**

4.3.3. Manganese in plants:

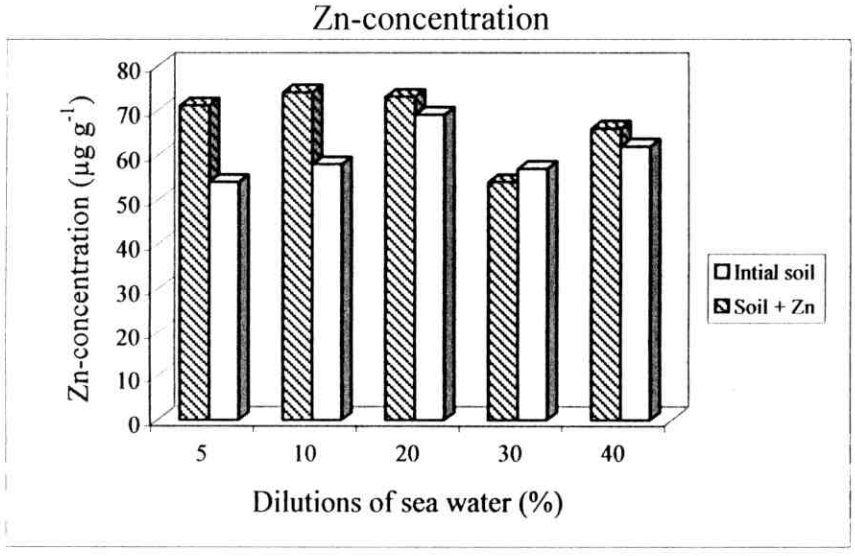
I. Manganese concentration:

After 45 days from sowing, data presented in Table (13) show that irrigating the soil which did not receive Mn with the different dilutions of the sea water, i.e., 5, 10, 20, 30 and 40 % of the sea water strength increased significantly concentration of Mn in barley plant from 133 to 198, 211, 203, 166 and 174 µg g^{-1}, respectively.

Table (13): Mn concentration and uptake by barley plants after 45 days from sowing as affected by soil irrigation with different dilutions of sea water.

Treatments	Mn concentration ($\mu g\ g^{-1}$)		Mn uptake ($\mu g\ pot^{-1}$)	
	Initial soil	Soil + Mn	Initial soil	Soil + Mn
Tap water (control)	133		470.82	
5 % of sea water	198	210	706.86	732.90
10 % of sea water	211	221	717.40	729.30
20 % of sea water	203	175	535.90	519.75
30 % of sea water	166	127	405.04	414.02
40 % of sea water	174	195	398.46	581.10
Average	190.4	185.6	552.73	595.41
LSD (0.05):	1.0	1.7	2.00	2.99

* Each value is a mean of three replicates.



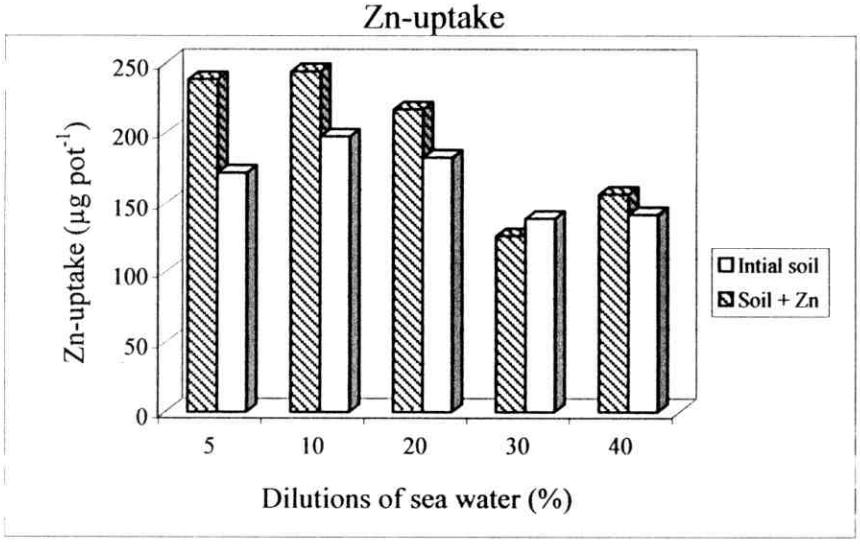


Fig. (10): Effect of irrigation with dilutions of sea water on Zn concentration and uptake by barley plants (after 45 days of sowing).

Addition of Mn at the rate of 5 μg g^{-1} under the same irrigation treatments increased significantly concentration of Mn to 210, 221, 175 and 195 μg g^{-1} corresponding to irrigation with the dilutions 5, 10, 20 and 40 % of the sea water strength. Only, the dilution corresponding to 30 % of the sea water strength decreased significantly Mn concentration to 127 μg g^{-1}.

After 90 days from sowing, data presented in Table (14) show that in the initial soil concentration of Mn in barley shoots increased significantly from 52 to 54, 64, 78 and 86 μg g^{-1} under irrigation with the dilutions corresponding to 5, 20, 30 and 40 % of sea water strength. In barley seeds, concentration of Mn increased significantly from 27 to 37, 36, 38, 48 and 48 μg g^{-1}, respectively

Addition of Mn at the rate of 5 μg g^{-1} to the same levels of sea water dilutions increased significantly concentration of Mn in barley shoots to 87, 99, 81, 83 and 92 μg g^{-1}, respectively. In seeds, concentration of Mn increased significantly to 39, 46, 36, 42 and 57 μg g^{-1}, respectively.

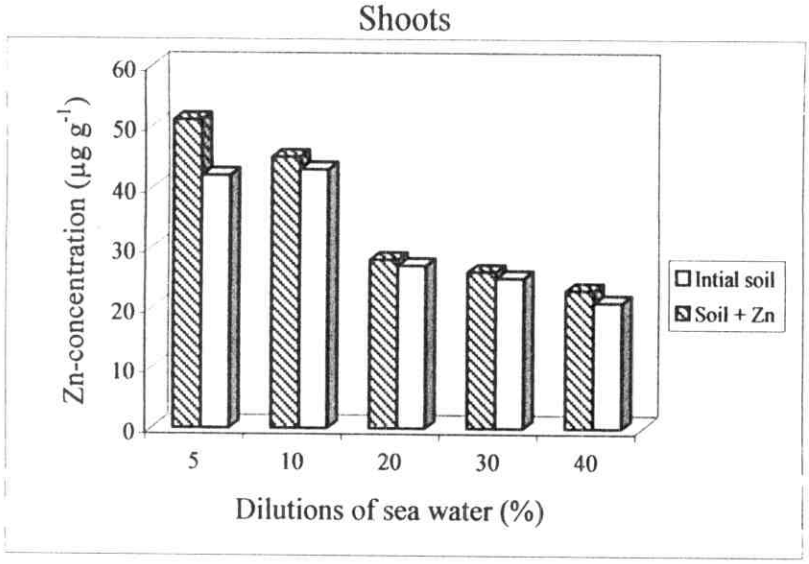
II. Manganese uptake by plants:

After 45 days from sowing, data presented in Table (13) show that in the initial soil, Mn uptake increased significantly from 470.82 μg pot^{-1} to 706.86, 717.40 and 535.9 μg pot^{-1} under the irrigation with the dilutions corresponding to 5, 10 and 20 % of sea water strength, respectively. On the other hand, shoots uptake of Mn decreased significantly to 405.04 and 398.46 μg pot^{-1} when salinity of the irrigation water was raised to 30 and 40 % of sea water strength.

Table (14): Mn concentration and uptake by barley plants after 90 days from sowing as affected by soil irrigation with dilutions of sea water.

Treatments	Mn concentration (µg g^{-1} plant)				Mn uptake (µg pot^{-1} plant)			
	Initial soil		Soil + Mn		Initial soil		Soil + Mn	
	shoots	seeds	shoots	seeds	shoots	seeds	shoots	seeds
Tap water (control)	52	27			214	52		
5 % of Sea water	54	37	87	39	225	74	421	102
10 % of Sea water	52	36	99	46	284	75	329	88
20 % of Sea water	64	38	81	36	183	78	227	59
30 % of Sea water	78	48	83	42	176	62	164	45
40 % of Sea water	86	48	92	57	153	53	190	69
Average	72.8	41.4	88.4	44.0	204	68.4	266	73
LSD (0.05):	1.9	1.7	1.7	2.1	2.1	2.1	1.0	2.1

* Each value is a mean of three replicates.



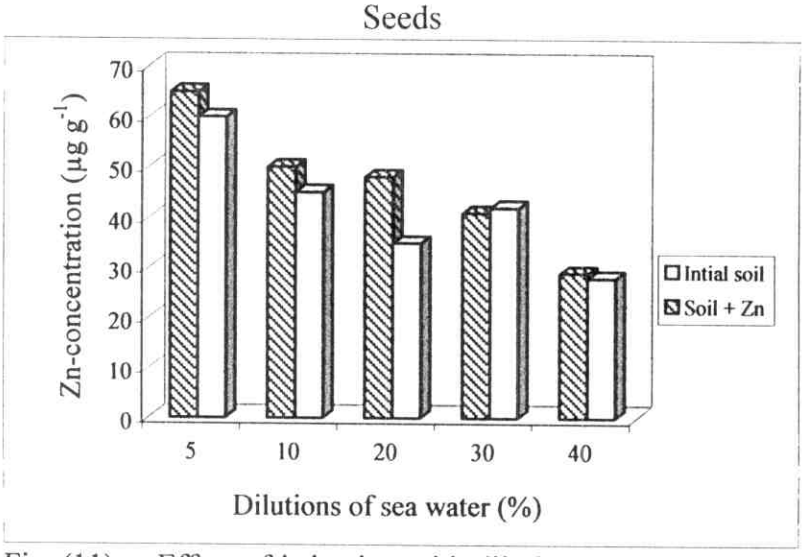
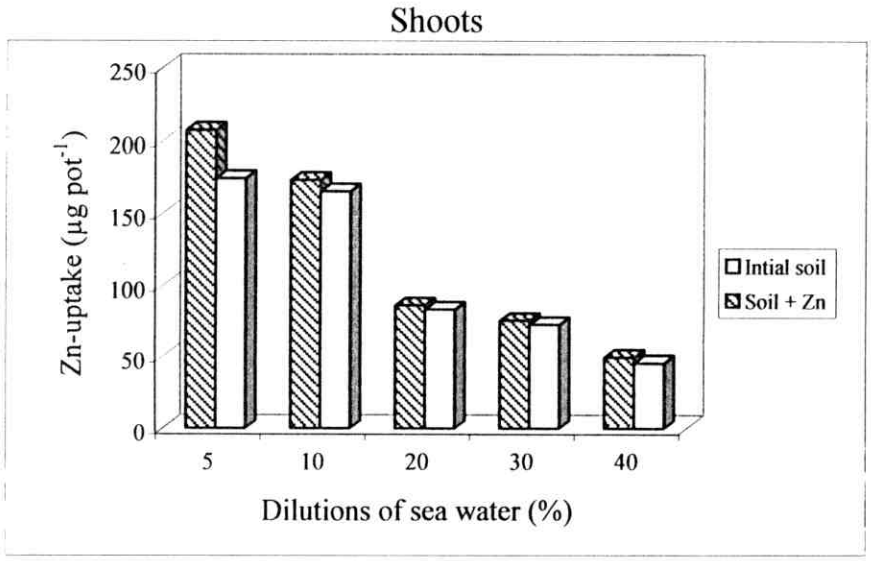


Fig. (11): : Effect of irrigation with dilutions of sea water on Zn concentration in barley plants (after 90 days of sowing).



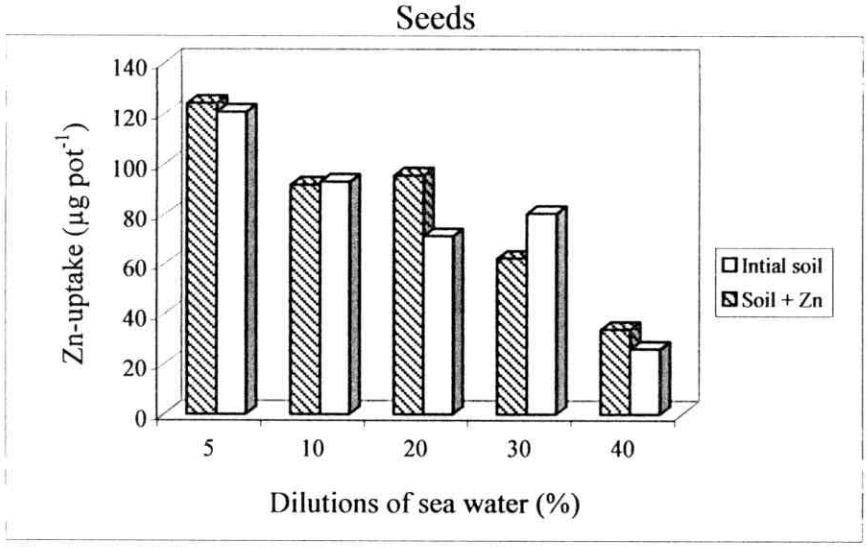


Fig. (12): Effect of irrigation with dilutions of sea water on Zn uptake by barley plants (after 90 days of sowing).

Addition of Mn at the rate of 5 μg g^{-1} under the same irrigation treatments increased significantly Mn uptake by plant to 732.90, 729.30, 519.75 and 581.10 when the dilutions used for irrigation were corresponding 5, 10, 20 and 40 % of the sea water strength. However, irrigating such a soil with the dilution corresponding to 30 % of the sea water strength reduced significantly Mn uptake by shoots from 470.82 to 414.02 μg pot^{-1}.

After 90 days from sowing, data presented in Table (14) show that in the initial soil Mn uptake by barley shoots increased significantly from 214 to 225 and 284 μg pot^{-1} due to irrigation with the dilutions corresponding to 5 and 10 % of the sea water strength. Increasing salinity of the irrigation water to 20, 30 and 40 % of the sea water strength caused Mn uptake by shoots to be significantly reduced to 183, 176 and 153 μg pot^{-1}, respectively.

In seeds, Mn uptake increased significantly from 52, to 74, 75, 78, 62 and 53 μg pot^{-1} under the studied irrigation treatments i.e., 5, 10, 20, 30 and 40 %, respectively of the sea water strength.

Addition of Mn at the rate of 5 μg g^{-1} under the same irrigation treatments increased significantly Mn uptake by barley shoots from 214 to 421, 329 and 227 μg pot^{-1} under the irrigation treatments corresponding to 5, 10 and 20 % of the sea water strength. On the other hand, increasing salinity of the applied water to 30 and 40 % of the sea water strength resulted in reduced value of Mn uptake by shoots of about 164 and 190 μg pot^{-1}, respectively.

In seeds, Mn uptake increased significantly from 52 µg pot^{-1} to 102, 88, 59 and 69 µg pot^{-1} at the rate of 5, 10, 20 and 40 % of sea water strength, respectively. An exception was noticed where Mn uptake was significantly decreased under irrigation with the dilution corresponding to 30 % of the sea water strength. **Rahman et al. 1993** suggested an antagonistic phenomenon between Na and both Mn and Zn uptake by maize plants.

4.3.4. Zinc in plants:

I. Zinc concentration:

After 45 days from sowing barley plant in the studied soil, data presented in Table (15) show that Zn concentration in the plant increased to 54, 58 and 69 µg g^{-1} under irrigation with the dilutions corresponding to 5, 10, 20, 30 and 40 %, respectively of the sea water strength as compared with 52 µg Zn g^{-1} plant in the control treatment that was irrigated with tap water.

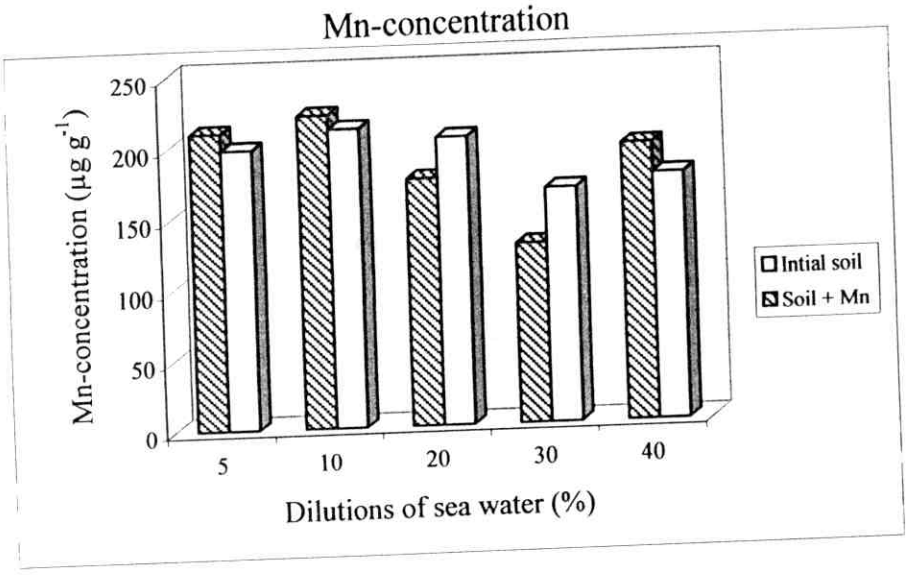
Addition of Zn at the rate of 5 µg g^{-1} under irrigation with the dilutions corresponding to 5, 10, 20, 30 and 40 % of the sea water strength increased significantly Zn concentration in the plant to 71, 74, 73, 54 and 66 µg g^{-1}, respectively.

After 90 days from sowing barley plant in the studied soil, data presented in Table (16) show that Zn concentration in shoots increased significantly from 20 µg g^{-1} to 42, 43, 27, 25 and 21 µg Zn g^{-1} plant due to using dilutions corresponding to 5, 10, 20, 30 and 40 % of the sea water strength. In seeds, Zn concentration increased significantly from 21 µg g^{-1} to 60.45,

Table (15): Zn concentration and uptake by barley plants as affected by soil irrigation with dilutions of sea water (after 45 days from sowing).

Treatments	Zn concentration ($\mu g\ g^{-1}$)		Zn uptake ($\mu g\ pot^{-1}$)	
	Initial soil	Soil + Zn	Initial soil	Soil + Zn
Tap water (control)	52		184.08	
5 % of sea water	54	71	171.36	238.56
10 % of sea water	58	74	197.20	244.20
20 % of sea water	69	73	182.16	216.81
30 % of sea water	57	54	139.08	126.36
40 % of sea water	62	66	141.98	156.42
Average	60	67.6	166.36	196.47
LSD (0.05):	4.9	3.1	3.49	0.60

* Each value is a mean of three replicates.



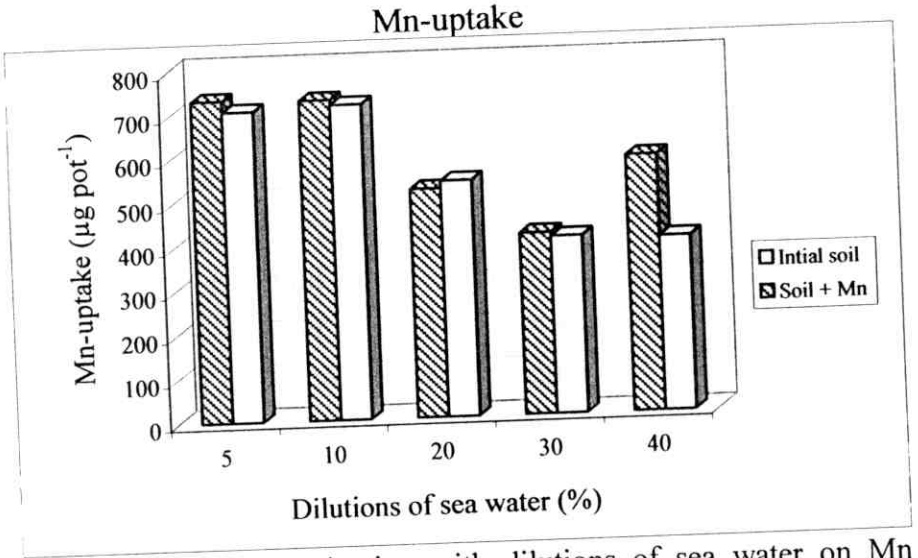


Fig. (13): Effect of irrigation with dilutions of sea water on Mn concentration and uptake by barley plants (after 45 days of sowing).

35.42 and 28.00 µg g^{-1} due to the irrigation with the aforementioned dilutions.

Addition of Zn at the rate of 5 µg g^{-1} with the aforementioned dilutions i.e., 5, 10, 20, 30 and 40 % of the sea water strength, also Zn concentration in shoots increased significantly to 51, 45, 28, 26 and 23 µg g^{-1}, and Zn concentration in seeds decreased significantly to 65, 50, 48, 41 and 29 µg g^{-1}, respectively.

II. Zinc uptake by plants:

After 45 days from sowing barley plant in the studied soil, data presented in Table (15) show that values of Zn uptake were as follows: 184.08, 171.36, 197.20, 182.16, 139.08 and 141.98 µg pot^{-1}, respectively upon irrigation of the soil with tap water and the dilutions corresponding to 5, 10, 20, 30 and 40 % of sea water strength.

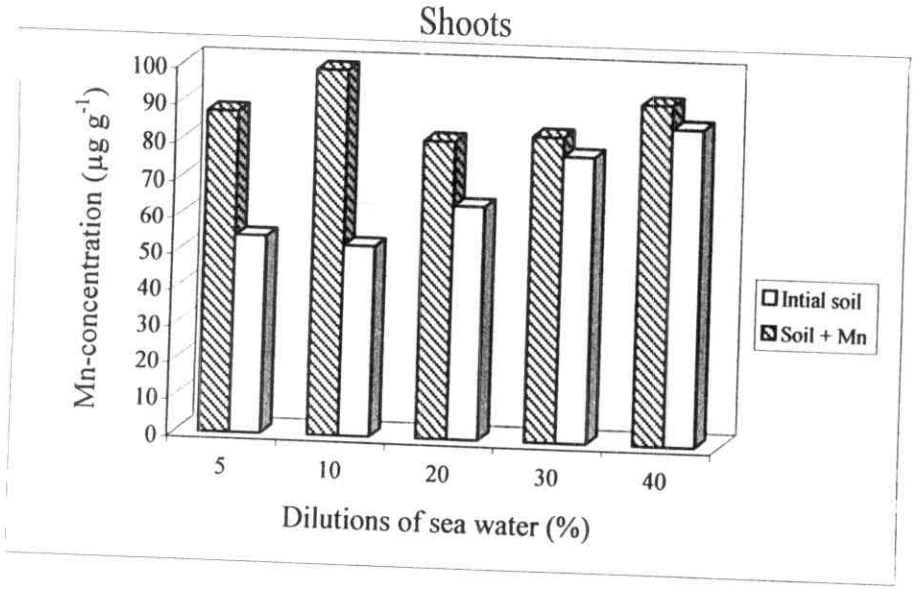
Addition of Zn at the rate of 5 µg g^{-1} under irrigation with the dilutions 5, 10 and 20 % of the sea water strength increased significantly Zn uptake by barley plant to 238.56, 244.20 and 216.81 µg pot^{-1}, respectively. Then, however, values of Zn uptake decreased significantly to 126.36 and 156.42 µg pot^{-1} when salinity of the irrigation water was raised up to 30 and 40 % of the sea water strength, respectively.

After 90 days from sowing barley plant in the soil which did not receive Zn, data presented in Table (16) show that Zn uptake in shoots increased significantly from 82 µg g^{-1} to 174, 165 and 183 µg g^{-1} when this soil was irrigated with the dilutions corresponding to 5, 10 and 20 % of the sea water strength.

Table (16): Zn concentration and uptake by barley plants after 90 days from sowing as affected by soil irrigation with dilutions of sea water.

Treatments	Zn concentration (µg g^{-1} plant)				Zn uptake (µg pot^{-1} plant)			
	Initial soil		Soil + Zn		Initial soil		Soil + Zn	
	shoots	Seeds	Shoots	seeds	shoots	seeds	shoots	seeds
Tap water (control)	20	21			82	44		
5 % of sea water	42	60	51	65	174	120.60	207	124.15
10 % of sea water	43	45	45	50	165	93.15	173	92.00
20 % of sea water	27	35	28	48	83	71.40	86	95.52
30 % of sea water	25	42	26	41	72	80.64	75	62.32
40 % of sea water	21	28	23	29	45	26.04	49	33.93
Average	31.6	42	34.6	46.6	108	81	118	83.58
LSD (0.05):	1.3	4.7	2.1	1.0	2.5	2.75	2.61	1.60

* Each value is a mean of three replicates.



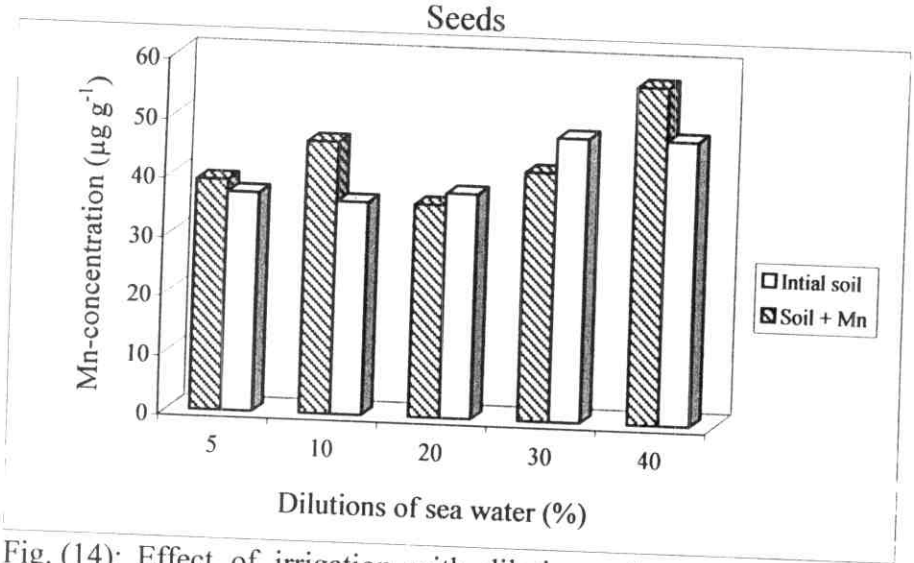
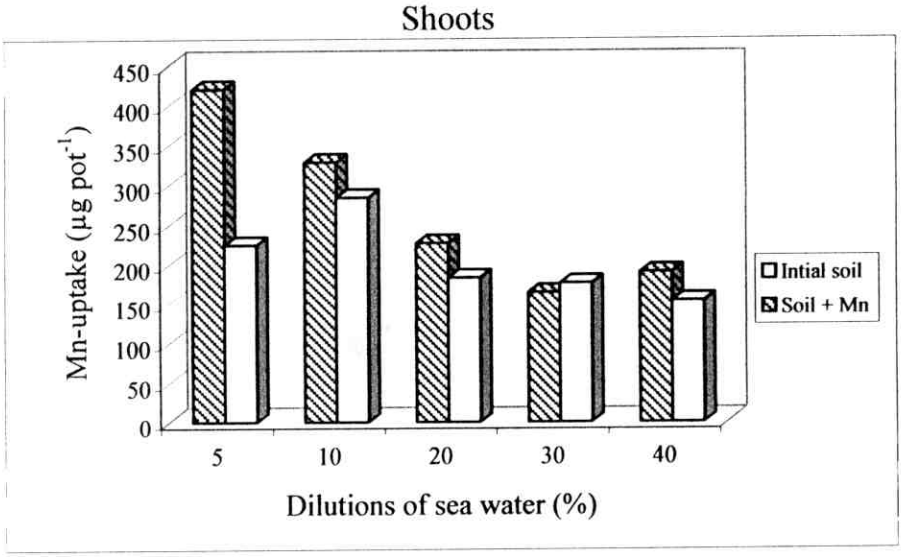


Fig. (14): Effect of irrigation with dilutions of sea water on Mn concentration in barley plants (after 90 days of sowing).



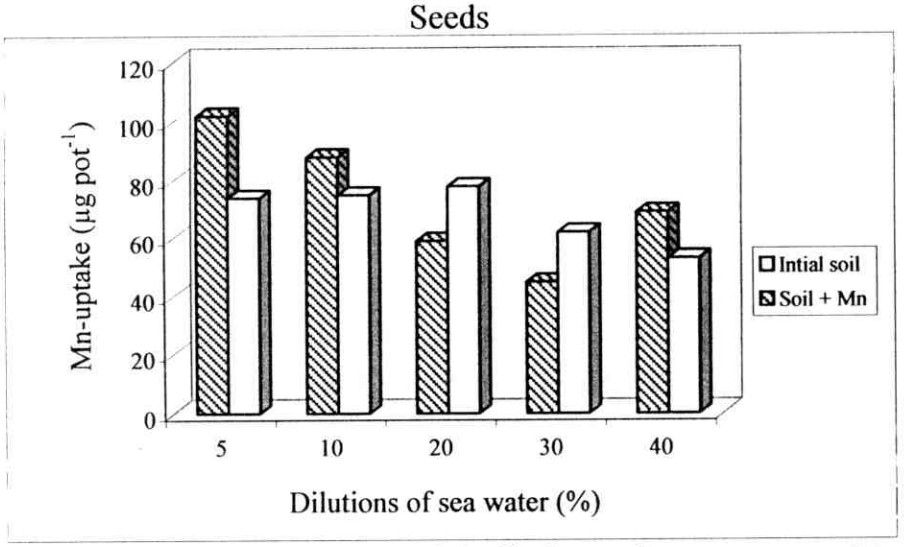


Fig. (15): Effect of irrigation with dilutions of sea water on Mn uptake by barley plants (after 90 days of sowing).

However, increasing salinity of the irrigation water to 30 and 40 % of the sea water strength caused shoots uptake of Zn to be significantly reduced to 72 and 45 μg Zn g^{-1}.

Zn uptake seemed to increase due to usage of the different dilutions of the sea water for irrigating soil in absence of applied Zn. One exception was observed with the water of the highest salinity i.e., 40 % of the sea water strength where Zn uptake by shoots decreased significantly to 26.04 μg g^{-1}.

Addition of Zn at the rate of 5 μg g^{-1} under irrigation with the used sea water dilutions (5, 10 and 20 % of sea water strength) increased significantly Zn uptake by shoots to 207, 173 and 86 μg pot^{-1}, respectively. Then, it decreased significantly to 75 and 49 μg pot^{-1} when salinity of the irrigation water was raised up to 30 and 40 % of the sea water strength, respectively. Also, Zn uptake by seeds of barley plant increased significantly to 124.15, 92.00, 95.52, and 62.32 μg pot^{-1}, respectively when the dilutions used for irrigations were equivalent to 5, 10, 20 and 30 % of the sea water strength. On the other hand, further increase in salinity of irrigation water to 40 % of the sea water strength obviously decreased Zn uptake by seeds to only 33.93 μg g^{-1}. These results are in agreement with those obtained by **Amer et al. 1999, Reda and Amer 1999** and **Noufal 2000**.