Experiment I

The Response of *Zea mays* Plant to Various Levels of Salinity or Vitamins Application.

The study presented here was conduced to investigate the changes that might take place in the growth parameters of *Zea mays* cv single cross 10 subjected to different salinity levels (0.0, 50, 100, 200, 300, 400 and 500 mM NaCl) as well as presowing the grains or spraying the shoots with 0.0, 50, 100, 200, 300, 400 and 500 ppm of vitamin pp (Nicotinamide) or vitamin C (Ascorbic acid).

Results

Effect of salinity:

It is demonstrated from Tables 1a-1d that increasing NaCl concentration from 50 to 200 mM significantly and progressively decreased shoot length, number of leaves and their area per plant, root length, number of adventitious roots per plant, fresh and dry weights of shoots and roots per plant as compared with those of the corresponding controls. The maximum reduction was obtained by applying 200 mM NaCl. The reductions were shown to be 48.02 % in shoot length, 47.5 % in area of leaves per plant, 66.4% in shoot fresh weight, 62.8% in shoot dry weight, 53.1% in root fresh weight and 71.4% in the root dry weight as compared with those of the percentage of corresponding control plants respectively.

In addition, the salinity levels above 200 mM (300, 400 and 500 mM) induced great injurious effects on the growth of *Zea mays* plants and consequently the plants failed to survive.

Effect of vitamins:

It is clearly shown from Tables 1a-1d and Figs 1a-1d that the best concentration used from the different vitamin levels (50, 100, 200, 300, 400 and 500 ppm) of nicotinamide (vit. pp) or ascorbic acid (vit c) in either grain soaking or shoot spraying that giving the maximum stimulation in most growth parameters in the tested *Zea mays* plant is 100 ppm.

The highest values of shoot length, area of leaves per plant and dry weight of shoot per plant recorded in both spraying and soaking treatments were 136.6 %, 165.0 % of 173.0 and 132.6 %, 134.0 %, 141.1 %, respectively in case of nicotinamide and 159.2%, 157.4%, 160.9 % and 156.4%, 143.2% and 151.5%, respectively in case of ascorbic acid as compared with those of the corresponding controls.

These results indicate that spraying treatment was more effective than soaking treatment in both vitamins.

From this experiment, one can conclude that 50, 10 and 200 mM NaCl are the suitable concentrations for further study and 100 ppm of both vitamins; nicotinamide and ascorbic acid is the most effective concentration in stimulating *Zea mays* plants and the spraying treatment is the most efficient.

Table (1a): Effects of salinity or vitamins on shoot growth criteria of *Zea mays* plants at 40 days from sowing. Values are expressed as means of 3 independent samples.

Treatment			Shoot length (cm/plant)	%	No of Leaves /plant	%	Area of leaves (cm^2/plant)	%
Salinity mM NaCl		0.0	20.2	100.0	4.6	100.0	30.91	100.0
		50	20.08	99.40	3.8*	82.6	33.24	164.5
		100	14.9**	73.76	3.2**	69.56	24.02**	77.7
		200	10.5**	51.98	2.8**	60.86	16.76**	52.5
		300	00.0		00.0		00.0	
		400	00.0		00.0		00.0	
		500	00.0		00.0		00.0	
Vit. pp (nicotinamide) ppm	Sprayed	50	22.5**	111.38	4.6	100.0	42.19**	136.4
		100	27.6**	136.6	4.6	100.0	51.00**	165.0
		200	27.3**	135.14	4.6	100.0	48.67**	157.4
		300	27.0**	133.6	4.6	100.0	42.99**	139.0
		400	26.7**	132.1	4.4	95.65	37.87**	122.5
		500	25.2**	124.7	4.0	86.95	26.13**	94.5
	Soaked	50	21.12	104.5	4.6	100.0	35.18*	113.8
		100	26.8**	132.6	4.6	100.0	41.45**	134.0
		200	24.4**	120.7	4.6	100.0	40.37**	130.6
		300	23.28**	115.2	4.4	95.65	39.12**	126.5
		400	22.7**	112.3	4.2	91.3	35.72**	115.5
		500	21.3	105.4	4.2	91.3	31.19	100.9
Vit. C (ascorbic acid) ppm	Sprayed	50	23.3**	115.3	4.6	100.0	34.59*	111.9
		100	32.16**	159.2	4.8	104.34	48.68**	157.5
		200	31.3**	154.9	4.2	91.3	42.45**	137.3
		300	28.4**	140.5	4.4	95.65	37.65**	121.8
		400	28.4**	140.5	4.4	95.65	37.61**	121.6
		500	22.6**	111.8	3.8*	82.6	36.26**	117.3
	Soaked	50	27.7**	137.1	4.6	100.0	35.96**	116.3
		100	31.6**	156.4	4.8	104.34	44.29**	143.2
		200	31.6**	156.4	4.6	100.0	43.24**	139.8
		300	28.2**	139.6	4.4	95.65	39.15**	126.6
		400	26.0**	128.7	4.0	86.95	37.74**	122.0
		500	20.4	100.9	4.0	86.95	34.48*	111.5
L.S.D. at 5 %			1.64		0.686		3.26	
L.S.D. at 1 %			2.19		0.91		4.36	

* Significant differences ** Highly significant differences as compared with reference controls

Table (1b): Effects of salinity or vitamins on root length (cm/plant) and number of adventitious roots of *Zea mays* plants at 40 days from sowing. Values are expressed as means of 3 independent samples.

Treatment			Root length (cm/plant)	%	No. of Adventitious roots /plant	%
Salinity mM NaCl		0.0	19.82	100.0	16.4	100.0
		50	17.98*	90.7	13.4**	81.7
		100	14.84**	74.8	10.8**	65.8
		200	11.13**	56.15	8.9**	54.2
		300	00.0		00.0	
		400	00.0		00.0	
		500	00.0		00.0	
Vit. pp (nicotinamide) ppm	Sprayed	50	39.6**	199.7	16.7*	101.8
		100	41.78**	210.7	18.2*	110.9
		200	40.2**	202.8	15.6	95.12
		300	39.66**	200.1	15.2	92.6
		400	36.88**	186.0	14.0**	85.3
		500	27.4**	138.2	12.0**	73.6
	Soaked	50	21.18**	106.8	14.2*	96.5
		100	24.14**	121.7	19.4**	118.2
		200	23.84**	120.2	17.2	104.8
		300	23.32**	117.6	15.0	91.4
		400	23.24**	117.2	15.8	96.3
		500	22.72**	114.6	14.6*	89.0
Vit. C (ascorbic acid) ppm	Sprayed	50	40.12**	102.4	14.4*	87.8
		100	44.66**	225.3	17.0	103.6
		200	38.78**	195.6	13.2**	80.4
		300	24.9**	125.6	14.4*	87.8
		400	24.84**	125.3	14.6*	89.0
		500	19.92	100.5	14.2*	86.5
	Soaked	50	32.6**	164.4	17.4	106.0
		100	41.38**	208.7	17.8	108.5
		200	39.54**	199.4	16.8	102.4
		300	38.34**	193.4	16.4	100.0
		400	36.5**	184.1	16.2	98.7
		500	35.2**	177.5	15.2	92.6
L.S.D. at 5 %			1.64		1.68	
L.S.D. at 1 %			2.19		2.24	

* Significant differences ** Highly significant differences as compared with reference controls

Table (1c): Effects of salinity or vitamins on the shoot weight (g/plant) of *Zea mays* plants at 40 days from sowing. Values are expressed as means of 3 independent samples.

Treatment			Shoot weight (g/plant)			
			Fresh	%	Dry	%
Salinity mM NaCl		0.0	4.76	100.0	0.574	100.0
		50	4.62	97.0	0.564	98.2
		100	2.72*	57.1	0.316**	55.0
		200	1.60**	33.6	0.214**	37.2
		300	00.0		00.0	
		400	00.0		00.0	
		500	00.0		00.0	
Vit. pp (nicotinamide) ppm	Sprayed	50	5.2	109.2	0.792*	137.9
		100	6.96**	146.14	0.994**	173.1
		200	6.47*	135.9	0.898**	156.4
		300	4.62	107.7	0.746*	129.9
		400	4.62	107.7	0.700	121.9
		500	3.14	55.9	0.468	91.5
	Soaked	50	5.03	105.6	0.581*	102.2
		100	6.52*	136.8	0.810**	141.1
		200	6.15	129.2	0.758*	132.0
		300	6.22	130.6	0.750*	130.6
		400	5.06	106.3	0.632	110.1
		500	4.31	90.5	0.518	90.2
Vit. C (ascorbic acid) ppm	Sprayed	50	5.11	107.3	0.597**	104.0
		100	7.02**	147.3	0.924*	160.9
		200	6.07	127.5	0.768	133.7
		300	5.94	124.7	0.704	122.6
		400	5.36	112.6	0.666	116.0
		500	4.74	99.5	0.584	101.7
	Soaked	50	5.14	107.9	0.666	116.0
		100	6.95**	134.2	0.870**	151.5
		200	6.75*	141.8	0.844**	147.0
		300	5.45	114.4	0.686	119.5
		400	5.08	106.7	0.652	113.5
		500	4.88	102.5	0.608	105.9
L.S.D. at 5 %			1.64		0.162	
L.S.D. at 1 %			2.19		0.22	

* Significant differences ** Highly significant differences as compared with reference controls

Table (1d): Effects of salinity or vitamins on the root weight (g/plant) of *Zea mays* plants at 40 days from sowing. Values are expressed as means of 3 independent samples.

Treatment			Root weight (g / plant)			
			Fresh	%	Dry	%
Salinity mM NaCl		0.0	2.106	100.0	0.374	100.0
		50	1.44	58.3	0.274	73.2
		100	1.14	54.1	0.150**	40.1
		200	0.989*	46.9	0.107**	28.6
		300	00.0		00.0	
		400	00.0		00.0	
		500	00.0		00.0	
Vit. pp (nicotinamide) ppm	Sprayed	50	2.18	103.8	0.50	133.6
		100	2.174	103.2	0.718**	191.9
		200	1.708	81.1	0.604**	161.9
		300	1.628	77.3	0.572	152.9
		400	1.212	57.5	0.486	129.9
		500	0.832*	39.5	0.356	95.1
	Soaked	50	2.12	100.9	0.268	71.6
		100	2.182	103.7	0.515*	137.7
		200	1.828	86.7	0.364	97.3
		300	1.798	85.3	0.344	91.9
		400	1.574	74.7	0.326	87.1
		500	1.172	55.6	0.258	58.9
Vit. C (ascorbic acid) ppm	Sprayed	50	2.205	105.0	0.391	104.5
		100	3.238*	153.7	0.590**	157.7
		200	2.354	111.7	0.372	99.4
		300	1.884	87.7	0.330	88.2
		400	1.844	87.5	0.324	86.6
		500	1.982	94.1	0.310	82.8
	Soaked	50	2.614	124.1	0.382	102.1
		100	3.4*	142.6	0.562*	150.2
		200	2.684	127.4	0.401	107.2
		300	2.552	121.1	0.400	106.2
		400	2.188	103.8	0.352	94.1
		500	2.076	98.5	0.322	86.0
L.S.D. at 5 %			1.05		0.14	
L.S.D. at 1 %			2.11		0.21	

* Significant differences ** Highly significant differences as compared with reference controls

Experiment II

The Response of *Zea mays* Plant to Salinity and/or Vitamins (vit. pp or vit. C) Treatments.

A- Growth Parameters:

The changes in growth characteristics of corn plants in response to salinization and/or vitamins (vit.PP or vit.C) treatments are given in Tables 2a-2c and Plates 1-4.

Height of shoot and area of leaves per plant:

The results (Table2a and Plates 1-4) show that the measured parameters; height of shoot and leaf area sharply decreased with rise of NaCl levels reaching maximum reduction at 200 mM NaCl in height of shoot (49.89 %) and in area of leaves 38.96 % as compared with the value of unsalinized plant.

Vitamin treatments, generally induced highly significant increase in the values of shoot length and area of leaves ranged between 20.5 % to 67.8% (in shoot length) and from 11.1 to 133.7 (in area of leaves) in case of vit.PP and from 10.9 to 83.4 % (in shoot length) and from 10.8 to 121.5 % (in area of leaves) in case of vit.C treatments, as compared with the reference controls.

Table (2a): Interactive effects of salinity and vitamins (nicotinamide or ascorbic acid) on the height of shoots and area of leaves of *Zea mays* plants at 40 days from sowing. Values are expressed as mean of 3 independent samples.

Treatment		NaCl mM	Height of shoot (cm/plant)	%	Area of leaves (cm^2/plant)	%
Reference controls		00	28.30	100.0	48.26	100.0
		50	22.15**	100.0	37.50**	100.0
		100	20.12**	100.0	28.16**	100.0
		200	14.12**	100.0	18.80**	100.0
NaCl + 100 ppm Vit. pp	Sprayed	00	40.80**	144.1	57.62**	119.3
		50	27.20**	122.7	50.17**	133.7
		100	26.76**	133.0	44.01**	156.2
		200	22.00**	155.8	40.82**	217.1
	Soaked	00	34.30**	121.2	54.02**	111.1
		50	26.70**	120.5	53.90**	143.7
		100	29.20**	145.1	51.77**	183.8
		200	23.70**	167.8	43.95**	233.7
NaCl + 100 ppm Vit. C	Sprayed	00	37.75**	133.3	53.65**	111.1
		50	25.83**	116.6	41.57*	110.8
		100	22.33	110.9	37.26**	132.3
		200	19.83**	140.4	32.24**	171.4
	Soaked	00	34.83**	123.0	53.87**	111.6
		50	33.50**	151.2	51.30**	136.8
		100	31.80**	158.0	49.19**	174.6
		200	25.90**	183.4	41.65**	221.5
L.S.D. at 5 %			2.43		3.23	
L.S.D. at 1 %			3.14		4.18	

* Significant differences ** Highly significant differences as compared with reference controls

Root length and number of adventitious roots per plant:

Results obtained in Table 2b and Plates 1-4 show that root length and number of adventitious roots per plant were reduced by increasing the concentration of NaCl, except at 50 and 100 mM NaCl, where the value of root length approached that of the control. The maximum reduction in root length (52.05%) and number of adventitious roots (44.4%) were observed at 200 mM NaCl as compared with control plants.

In general, application of nicotinamide (vit. pp) or ascorbic acid (vit. C) resulted in a high significant increase in both root length and number of adventitious roots of the test plants in comparison with those of plants subjected only to the corresponding levels of salinity. The maximum increases in both root length and number of adventitious roots were about 153.04%, 148.6 and 193.7, 187.5%, respectively, when the plants treated with nicotinamide, and 227.4%, 200.2 and 203.7, 200.0 %, respectively, when the plants treated with ascorbic acid in case of soaking and spraying treatment, respectively.

Fresh and dry weights for both shoot and root per plant:

Result shown in Table 2c reveal that fresh and dry weights, of the roots and shoots of *Zea mays* plants under various levels of salinity were highly significantly reduced with increasing the salinity level. The highest inhibitory effect of salinity on fresh and dry weights was recorded at 200 mM NaCl in both shoot and root system. The shoot system appeared to be more sensitive to salinity

Table (2b): Interactive effects of salinity and vitamins (nicotinamide or ascorbic acid) on the root length and number of adventitious root of *Zea mays* plants at 40 days from sowing. Values are expressed as mean of 3 independent samples.

Treatment		NaCl mM	Root length (cm/plant)	%	Number of adventitious roots per plant	%
Reference controls		00	22.38	100.0	18.00	100.0
		50	22.49	100.0	16.07**	100.0
		100	21.90	100.0	13.60**	100.0
		200	11.65**	100.0	8.00**	100.0
NaCl + 100 ppm Vit. Pp	Sprayed	00	38.70**	172.9	18.60	103.3
		50	26.44**	117.5	17.00	105.7
		100	32.56**	148.6	17.00**	125.0
		200	15.14**	129.9	15.00**	187.5
	Soaked	00	24.83*	110.9	18.60	103.3
		50	24.00	106.7	18.00**	112.0
		100	22.00	100.4	16.00**	117.6
		200	17.83**	153.0	15.50**	193.7
NaCl + 100 ppm Vit. C	Sprayed	00	36.00**	160.8	19.40*	107.7
		50	34.95**	155.4	17.00	105.7
		100	32.42**	148.0	16.40**	120.5
		200	23.33**	200.2	16.00**	200.0
	Soaked	00	34.90**	155.9	19.00	105.5
		50	33.80**	150.2	19.00**	108.2
		100	31.33**	143.1	17.20**	126.4
		200	26.50**	227.4	16.30**	203.7
L.S.D. at 5 %			2.30		1.28	
L.S.D. at 1 %			2.98		1.66	

* Significant differences ** Highly significant differences as compared with reference controls.

than root system especially at the hight level used (200 mM NaCl). Vitamin treatments (soaking or spraying) had partially or completely alleviated the inhibitory effects of salt stress on fresh weight and dry matter yield of root and shoot system. Moreover, vitamin treatments did not only alleviate the inhibitory effect of salt stress, but also in some cases, induced a marked increase in fresh and dry weight. Where the range of increase in fresh weight of shoot ranged from 15.1 % to 176.9% and in case of dry weight ranged from 10 % to 133.3 %, but in case of root the percentage increase in fresh weight ranged from 2.8% to 80.3% and in dry weight from 2% to 75%, when the plants compared with those of the reference controls.

The stimulatory effect in fresh and dry weights was more obvious in shoot spraying with nicotinamide and grain soaking in ascorbic acid for both root and shoot system when compared with the corresponding controls.

Table (2c): Interactive effects of salinity and vitamins (nicotinamide or ascorbic acid) on fresh and dry weights for both shoot and root (g/plant) of *Zea mays* plants at 40 days from sowing. Values are expressed as mean of 3 independent samples.

Treatment		NaCl mM	Shoot weight (g/plant)				Root weight (g/plant)			
			Fresh	%	Dry	%	Fresh	%	Dry	%
Reference controls		00	7.98	100.0	1.00	100.0	2.80	100.0	0.50	100.0
		50	5.42**	100.0	0.70**	100.0	1.80**	100.0	0.37**	100.0
		100	4.31**	100.0	0.57**	100.0	1.61**	100.0	0.32**	100.0
		200	2.04**	100.0	0.30**	100.0	1.02**	100.0	0.20**	100.0
NaCl + 100 ppm Vit. Pp	Sprayed	00	11.67**	146.2	1.42**	142.0	3.11	111.7	0.55	110.0
		50	8.69**	160.3	1.03**	147.1	2.71**	150.5	0.46**	124.3
		100	7.21**	167.2	0.86**	150.8	2.13	132.2	0.40**	125.0
		200	5.50**	269.6	0.70**	233.3	1.82	178.4	0.30**	150.0
	Soaked	00	9.91*	124.1	1.14	114.0	3.79**	135.3	0.66**	132.0
		50	8.71**	160.7	1.07**	152.8	2.14	118.8	0.43*	116.2
		100	7.05**	163.5	0.87**	152.6	1.92	119.2	0.38*	118.7
		200	5.13**	261.4	0.63**	210.0	1.70*	166.6	0.30**	150.0
NaCl + 100 ppm Vit. C	Sprayed	00	9.65	120.9	1.20	120.0	2.98	106.4	0.52	104.0
		50	6.24	115.1	0.77	110.0	2.14	118.8	0.42	113.5
		100	5.67	131.5	0.70	122.8	2.03	126.0	0.40**	125.0
		200	4.63**	226.9	0.56*	186.6	1.84**	180.3	0.35**	175.0
	Soaked	00	9.63	120.6	1.19	119.0	2.88	102.8	0.51	102.0
		50	7.5*	138.3	0.92	131.4	2.72**	151.1	0.45**	121.6
		100	6.6*	153.1	0.85*	149.1	2.18*	135.4	0.43**	134.3
		200	5.65**	276.9	0.62**	206.6	1.75**	171.5	0.31**	155.0
L.S.D. at 5 %			1.81		0.22		0.56		0.06	
L.S.D. at 1 %			2.35		0.29		0.72		0.08	

* Significant differences ** Highly significant differences as compared with reference controls.

Salinity treatment

Control (H_2O) 50 Mm NaCl 100 Mm NaCl 200 Mm NaCl

Shoot spraying treatment

0.0 Mm NaCl + 100 ppm Vit. pp | 50 M m NaCl + 100 ppm Vit. pp | 100 Mm NaCl + 100 ppm Vit. pp | 200 Mm NaCl + 100 ppm Vit. Pp

Plate (1): Effect of increasing level of NaCl (0.0, 50, 100, and 200 mM) alone or in combination with vit.pp (nicotinamide) as shoot spraying on growth of *Zea mays* plant at 40 days from sowing .

Salinity treatment

Control (H_2O) 50 Mm NaCl 100 Mm NaCl 200 Mm NaCl

Grain soaking treatment

0.0 Mm NaCl + 100 ppm Vit. pp | 50 Mm NaCl + 100 ppm Vit. pp | 100 Mm NaCl + 100 ppm Vit. pp | 200 Mm NaCl + 100 ppm Vit. pp

Plate (2): Effect of increasing level of NaCl (0.0, 50, 100, and 200 mM) alone or in combination with vit.pp (nicotinamide) as grain soaking on growth of *Zea mays* plant at 40 days from sowing .

Salinity treatment

Control (H_2O) 50 Mm NaCl 100 Mm NaCl 200 Mm NaCl

Shoot spraying treatment

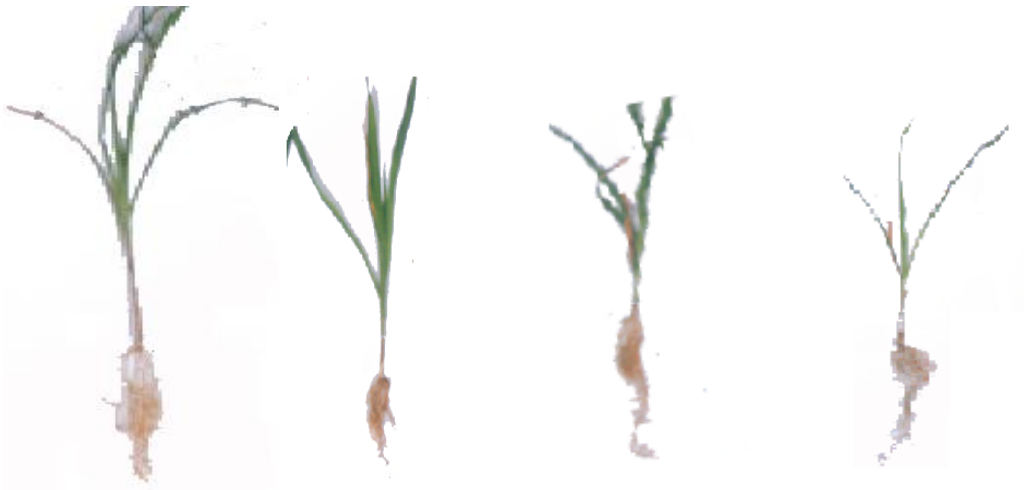
0.0 Mm NaCl + 100 ppm Vit. C | 50 Mm NaCl + 100 ppm Vit. C | 100 Mm NaCl + 100 ppm Vit. C | 200 Mm NaCl +100 ppm Vit. C

Plate (3): Effect of increasing level of NaCl (0.0, 50, 100, and 200 mM) alone or in combination with vit.c (ascorbic acid) as shoot spraying on growth of *Zea mays* plant at 40 days from sowing .

Salinity treatment

Control (H_2O) 50 Mm NaCl 100 Mm NaCl 200 Mm NaCl

Grain soaking treatment



0.0 Mm NaCl + 100 ppm Vit. C | 50 Mm Nacl + 100 ppm Vit. C | 100 Mm Nacl + 100 ppm Vit. C | 200 Mm Nacl + 100 ppm Vit. C

Plate (4): Effect of increasing level of NaCl (0.0, 50, 100, and 200 mM) alone or in combination with vit.c (ascorbic acid) as grain soaking on growth of *zea mays* plant at 40 days from sowing .

B- Metabolic activities:

1- Endogenous growth hormones:

The changes in the amounts of various endogenous growth hormones of *Zea mays* shoots as affected by different levels of NaCl and /or vitamins are given in Table 3 and Figs. 1a-1c. A retarding effect on the biosynthesis of IAA and GA_3 in *Zea mays* shoots and a stimulatory effect on the biosynthesis of ABA were observed in response to increasing concentration of NaCl.

Application of vitamin (vit.PP or vit.C) by spraying or soaking treatment resulted in a marked and progressive increase in the GA_3 and IAA levels and a decrease in ABA content. Vitamin treatments did not only alleviate the inhibitory or stimulatory effects of salinity, but also induced a stimulatory effect on the biosynthesis of GA_3, IAA and an inhibitory effect on ABA biosynthesis as compared with those of the reference controls.

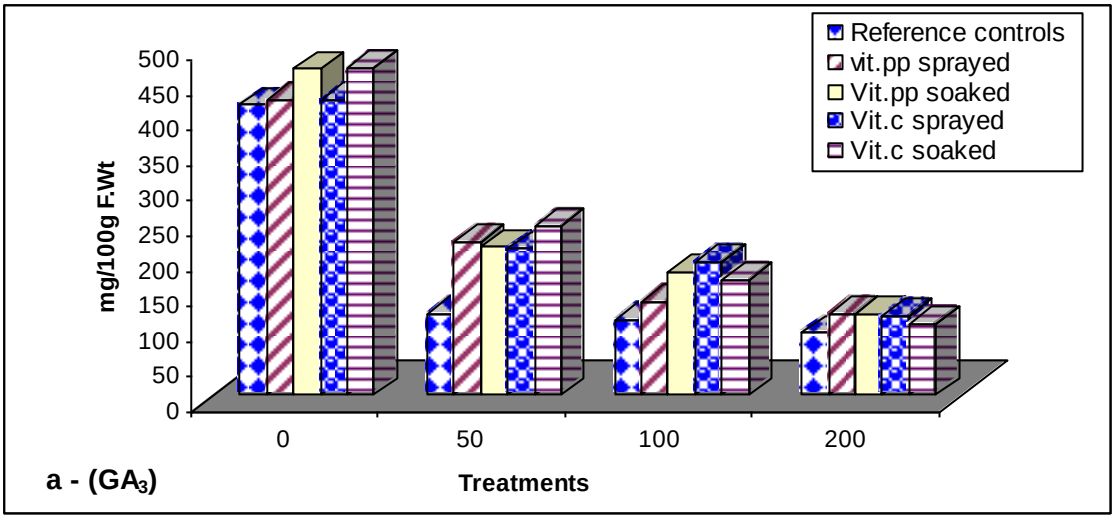
The maximum values of GA_3 and IAA were about 189.6% and 309.6%, respectively in case of vit.PP and 209.0 % and 261.9 % in case of vit.C, whereas the minimum values of ABA were about 49.7% and 59.12% in salinized *Zea mays* plants treated with vit.PP or vit.C, respectively.

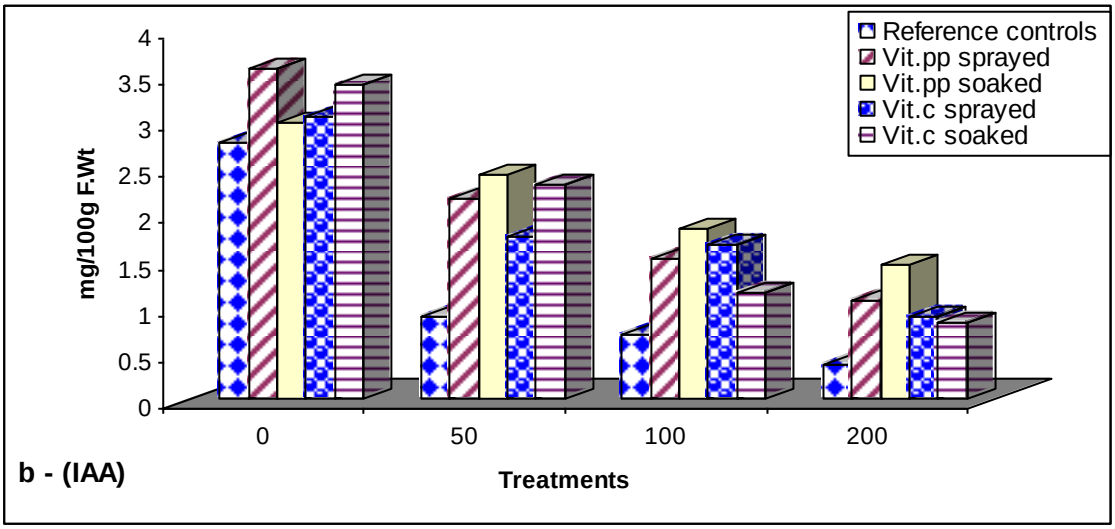
IAA biosynthesis is more sensitive to vitamin treatments than GA_3 in both vitamins application.

Table (3): Interactive effects of salinity and vitamins (nicotinamide or ascorbic acid) on hormone contents (mg/100g f.wt) of shoots of *Zea mays* plants at 40 days from sowing. Values are expressed as mean of 3 independent samples.

Treatment		NaCl mM	GA_3	%	IAA	%	ABA	%
Reference controls		00	411.59	100.0	2.776	100.0	0.835	100.0
		50	115.02**	100.0	0.882**	100.0	0.552*	100.0
		100	106.31**	100.0	0.693**	100.0	1.003	100.0
		200	88.11**	100.0	0.373**	100.0	1.188**	100.0
NaCl + 100 ppm Vit. pp	Sprayed	00	418.75**	101.7	3.567**	128.4	0.305**	36.52
		50	218.11**	189.62	2.168**	245.8	0.299*	54.16
		100	132.85**	124.96	1.524**	219.9	0.585**	58.32
		200	114.6**	133.5	1.057**	283.3	0.908*	76.43
	Soaked	00	463.18**	112.5	2.989	107.6	0.668	80.0
		50	210.54**	183.0	2.430**	275.5	0.371	67.21
		100	174.63**	164.2	1.833**	264.5	0.499**	49.7
		200	115.95**	131.5	1.453**	309.1	0.879*	73.9
NaCl + 100 ppm Vit. C	Sprayed	00	419.24**	101.8	3.040	109.5	0.340**	40.71
		50	207.73**	180.6	1.753**	198.7	0.374	67.75
		100	188.20**	177.0	1.660**	239.5	0.593**	59.12
		200	112.00**	127.1	0.879*	235.6	0.946	79.62
	Soaked	00	463.68**	122.6	3.388**	122.0	0.746	89.34
		50	240.42**	209.0	2.310**	261.9	0.351	63.58
		100	163.47**	153.4	1.137*	164.0	0.644**	64.20
		200	100.93**	114.5	0.815*	218.4	0.815**	68.60
L.S.D. at 5 %			2.71		0.43		0.25	
L.S.D. at 1 %			3.51		0.50		0.32	

* Significant differences ** Highly significant differences as compared with reference controls





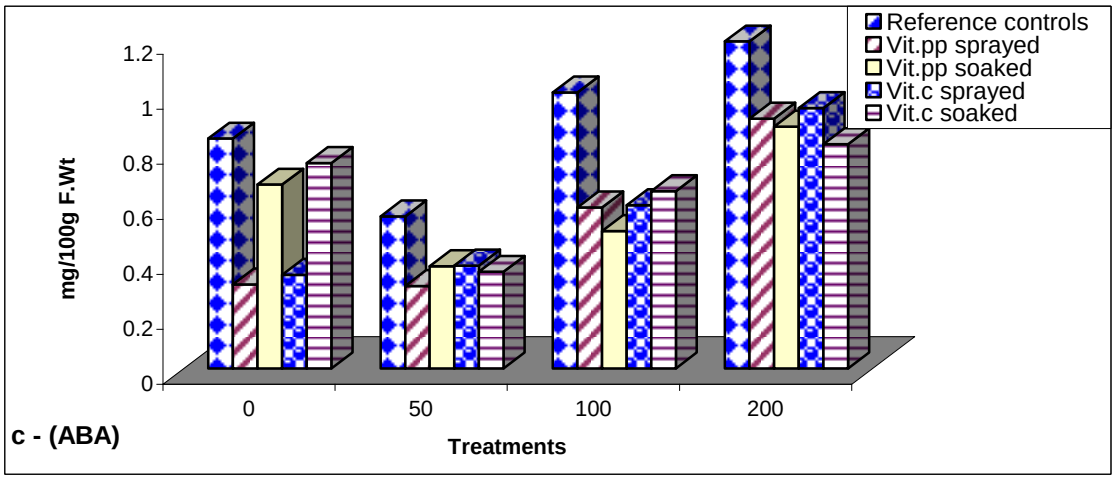


Fig (1a-1c): Interactive effects of salinity and vitamins (nicotinamide or ascorbic acid) on hormone contents (mg/100g f.wt) of shoots of *Zea mays* plants at 40 days from sowing. Values are expressed as mean of 3 independent samples.

2- Photosynthetic pigments:

The contents of photosyntheticaly active pigments (chlorophyll a, chlorophyll b and carotenoids) which estimated in the leaves of 40 day old treated maize plants are presented in Table 4 and Fig. 2a-2d. Chlorophyll a, chlorophyll b and carotenoid contents significantly reduced with increasing the salinity level as compared with those of the unsalinized plants. The highest inhibitory effect of salinity on chlorophyll a, chlorophyll b and carotenoid were recorded at 200 mM NaCl. Grain soaking in/or shoot spraying with any of the two vitamins (vit.PP or vit.C) did not only alleviate the inhibitory effects of salinity, but also, in all cases, induced a significant stimulatory effects on the biosynthesis of pigment fractions when compared with those of the corresponding salinized plants.

The maximum values of total pigments recorded in case of soaking and spraying treatments were 247.0% and 211.9 % in case of nicotinamide and ascorbic acid, respectively. In general the stimulatory effects of vitamins were much more pronounced in case of shoots sprayed with both nicotinamide and ascorbic acid, as compared with those of reference salinized controls.

3- Carbohydrate contents:

Carbohydrate fractions; soluble and insoluble sugars as well as total carbohydrate contents of *Zea mays* plants affected by salinity

Table (4): Interactive effects of salinity and vitamins (nicotinamide or ascorbic acid) on pigments (µg/g D.Wt) of leaves of *Zea mays* plants at 40 days from sowing. Values are expressed as mean of 3 independent samples.

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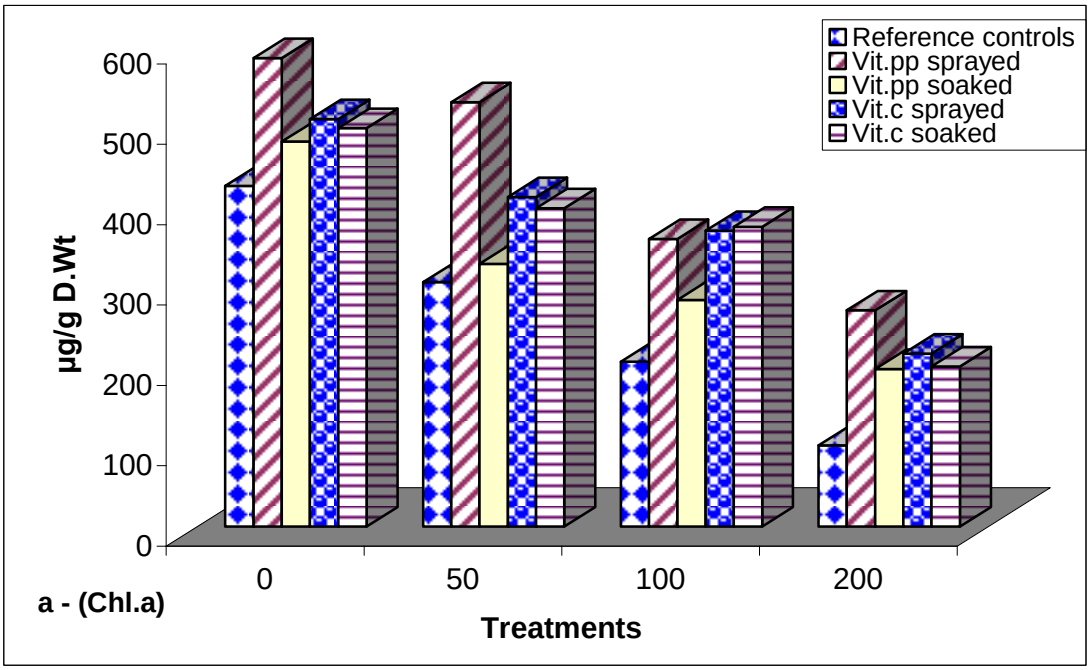
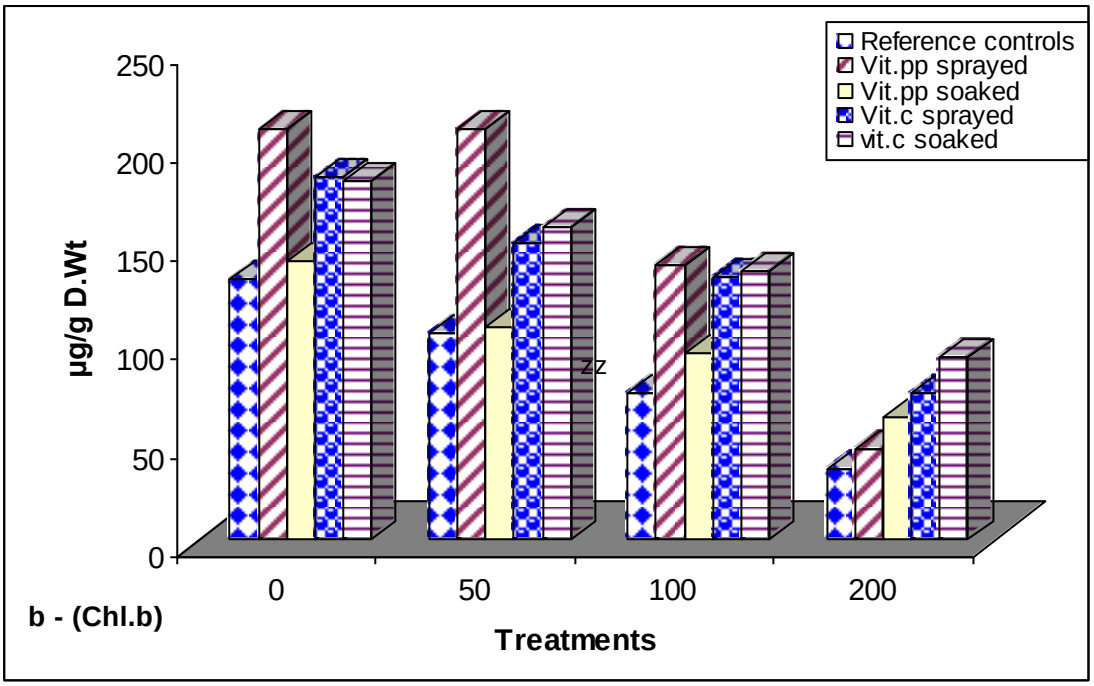
Treatment		NaCl mM	Ch. a	%	Chl. b	%	Carotenoids	%	Total pigments	%
Reference controls		00	424	100.0	132	100.0	134	100.0	691	100.0
		50	304**	100.0	104**	100.0	93**	100.0	502**	100.0
		100	205**	100.0	74**	100.0	67**	100.0	347**	100.0
		200	101**	100.0	35**	100.0	32**	100.0	168**	100.0
NaCl + 100 ppm Vit. pp	Sprayed	00	583**	137.5	208**	157.5	152*	113.4	944**	136.6
		50	528**	173.6	208**	200.0	128**	137.6	865**	172.3
		100	358**	172.1	139**	187.8	85*	126.8	578**	166.5
		200	269**	266.3	45	128.5	99**	309.3	415**	247.0
	Soaked	00	479**	112.9	141	106.8	148	110.4	769**	111.2
		50	327**	107.5	107	102.8	109*	117.2	544**	108.3
		100	282**	137.5	94*	127.0	88**	131.3	466**	134.2
		200	196**	194.0	62**	177.1	64**	200	323**	192.2
NaCl + 100 ppm Vit. C	Sprayed	00	507**	119.5	183**	138.6	150*	111.9	841**	121.7
		50	410**	134.8	150**	144.2	120**	129.0	681**	135.6
		100	368**	172.5	133**	172.7	107**	159.7	609**	175.5
		200	215**	212.8	74**	211.4	65**	203.1	356**	211.9
	Soaked	00	496**	116.9	181**	137.1	158**	117.9	835**	120.9
		50	396**	131.2	158**	151.9	137**	143.3	695**	138.4
		100	373**	181.9	136**	183.7	118**	176.1	628**	186.9
		200	199**	197.0	92**	962.8	31	96.8	322**	191.6
L.S.D. at 5 %			16.3		18.3		15.9		318	
L.S.D. at 1 %			21.1		23.7		20.6		412	

* Significant differences ** Highly significant differences as compared with reference controls.


Reference controls
Vit.pp sprayed
Vit.pp soaked
Vit.c sprayed
Vit.c soaked
600
500
400
300
200
100
0
µg/g D.Wt
0
50
100
200
Treatments
a - (Chl.a)


Reference controls
Vit.pp sprayed
Vit.pp soaked
Vit.c sprayed
vit.c soaked
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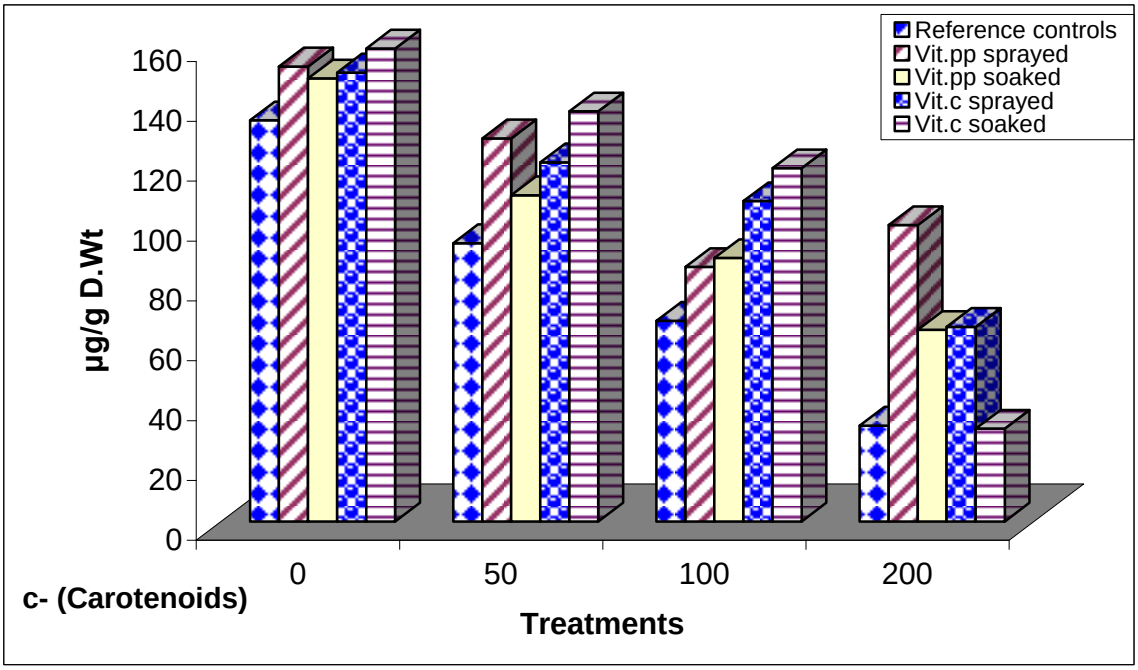
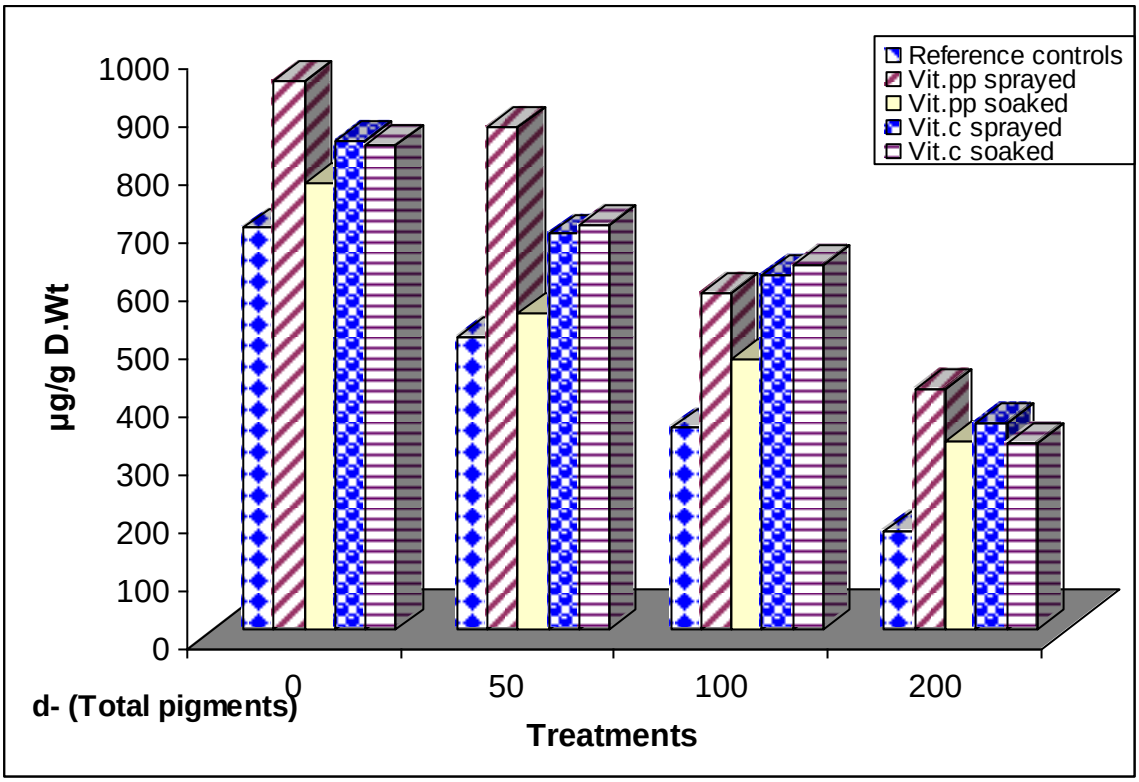
200
150
100
50
0
µg/g D.Wt
zz
0
50
100
200
Treatments
b - (Chl.b)





Fig(2a-2d): Interactive effects of salinity and vitamins (nicotinamide or ascorbic acid) on pigments (µg/g D.Wt) of leaves of *Zea mays* plants at 40 days from sowing. Values are expressed as mean of 3 independent samples.

and/or vitamins (nicotinamide or ascorbic acid) are given in Table 5 and fig. 3a-3c. The data clearly demonstrate that, salinity at 100 and 200 mM levels is capable of inducing decreases in most cases, in total soluble, insoluble and consequently total carbohydrate contents as compared with those of the non-salinized plant (control).

Grain soaking in and shoot spraying with any of the two vitamins (nicotinamide or ascorbic acid), resulted mostly in highly significant increases in the contents of carbohydrates fractions than those estimated in plants subjected to salinity alone, and consequently the inhibitory effect of salt was completely recovered or partially alleviated .

In general, it is noticeable that the stimulatory effect of vitamin treatments on salinized plants was more obvious in case of plants originating from soaked grains in vitamins than from shoots sprayed with vitamins.

The maximum value of total carbohydrate contents in test plant was about 159.3% in case of spraying nicotinamide and 149.0% in case of soaking grains in ascorbic acid.

Table (5): Interactive effects of salinity and vitamins (nicotinamide or ascorbic acid) on carbohydrate contents (mg glucose/100g D.Wt) of shoots of *Zea mays* plants at 40 days from sowing. Values are expressed as mean of 3 independent samples.

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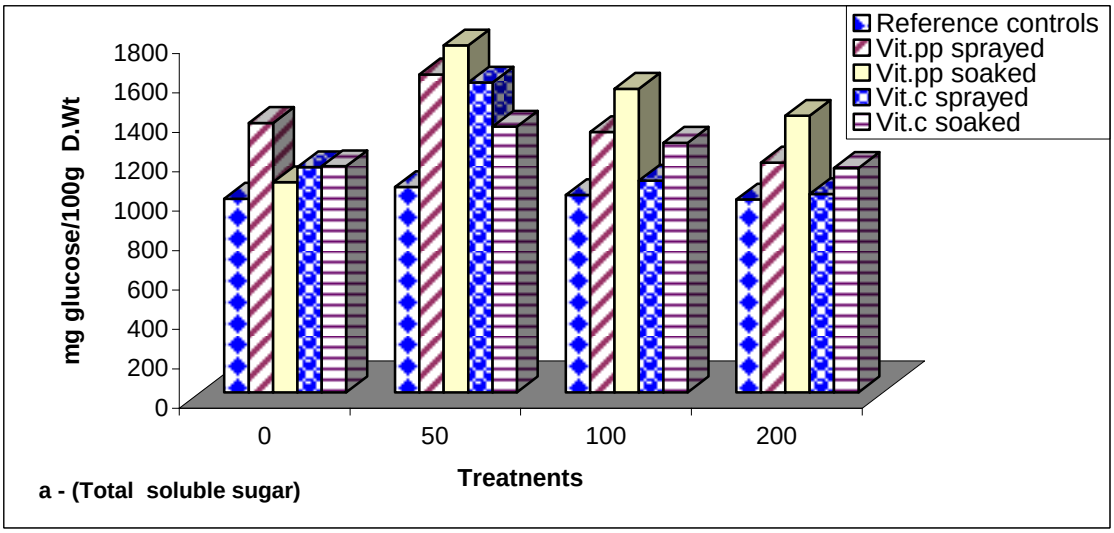
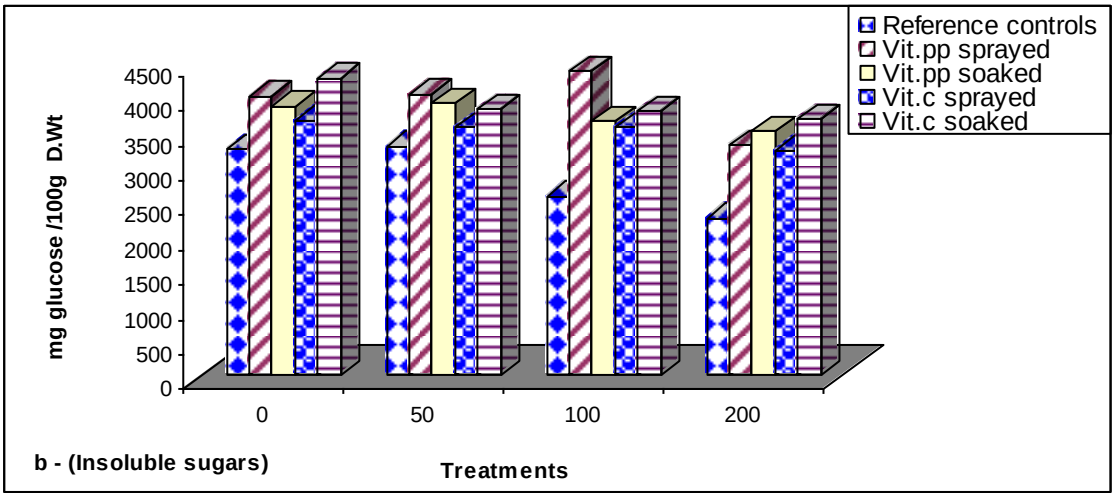
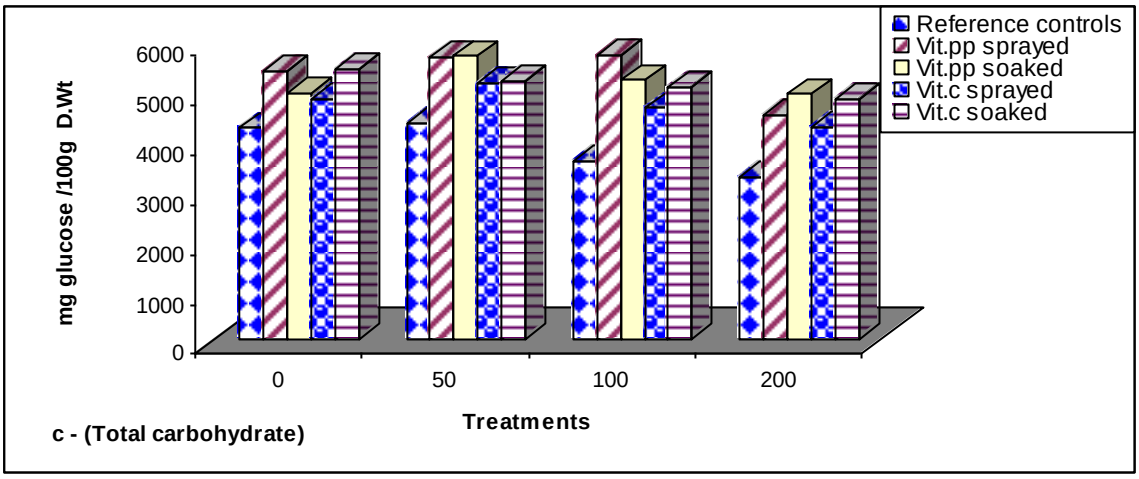
Treatment		NaCl mM	Total soluble sugar	%	Insoluble sugars	%	Total carbohydrate	%
Reference controls		00	982.85	100.0	3241.13	100.0	4223.9**	100.0
		50	1042.28**	100.0	3277.70**	100.0	4319.9**	100.0
		100	1001.13**	100.0	2559.99**	100.0	3561.1**	100.0
		200	978.27**	100.0	2249.13**	100.0	3227.4**	100.0
NaCl + 100 ppm Vit. pp	Sprayed	00	1366.84**	139.0	3999.9**	123.4	5366.8**	127.0
		50	1613.70**	154.8	4031.9**	123.0	5645.6**	130.6
		100	1321.13**	1131.9	4351.9**	170.0	5673.1**	159.3
		200	1165.71**	119.1	3305.13**	146.9	4470.8**	138.5
	Soaked	00	1065.71**	108.3	3853.7**	118.8	4918.8**	166.4
		50	1759.99**	168.8	3899.4**	118.9	5659.4**	131.0
		100	1540.56**	153.8	3643.4**	142.3	5183.9**	145.5
		200	1403.42**	143.4	3497.1**	155.4	4900.5**	151.8
NaCl + 100 ppm Vit. C	Sprayed	00	1142.85**	166.2	3652.5**	112.6	4795.4**	113.5
		50	1571.66**	138.6	3561.1**	108.6	5132.7**	118.8
		100	1074.28**	107.3	3547.4**	138.5	4621.7**	129.7
		200	1005.71**	102.8	3222.8**	143.2	4228.5**	131.0
	Soaked	00	1147.42**	116.7	4255.9**	131.3	5403.4**	127.9
		50	1348.56**	129.3	3807.9**	116.1	5156.5**	119.3
		100	1266.28**	126.4	3780.5**	147.6	5046.8**	141.7
		200	1138.28**	116.3	3670.8**	163.2	4809.1**	149.0
L.S.D. at 5 %			3.14		3.97		3.40	
L.S.D. at 1 %			4.07		5.14		4.40	

* Significant differences ** Highly significant differences as compared with reference controls.







Fig(3a-3c): Interactive effects of salinity and vitamins (nicotinamide or ascorbic acid) on carbohydrate contents (mg glucose/100g D.Wt) of shoots of *Zea mays* plants at 40 days from sowing. Values are expressed as mean of 3 independent samples.

4- Nitrogen constituents:

Nitrogen contents (total soluble-N, protein-N and total-N) of the shoot of maize plants subjected to various treatments of salinity and vitamins (nicotinamide or ascorbic acid) either grain soaking or shoot spraying are given in Table 6 and Fig. 4a-4c. The data clearly indicate that salt stress induced highly stimulatory effect on the production of total soluble-N while protein-N and total-N were consistently decreased with rise of salinity level.

Grain soaking and shoot spraying treatments with nicotinamide or ascorbic acid in control plants or under salinized ones, resulted in a highly significant increase in the biosynthesis of total-soluble-N, protein-N and consequently the total-N as compared with those of the reference controls. The maximum increases of nitrogen contents; T. soluble-N, protein-N and T. N in salinized maize plants treated with nicotinamide were about 20.0%, 53.9% and 46.5%,while in salinized plants treated with ascorbic acid were about 22.7%, 66.8% and 53.2% over those of the reference controls, respectively.

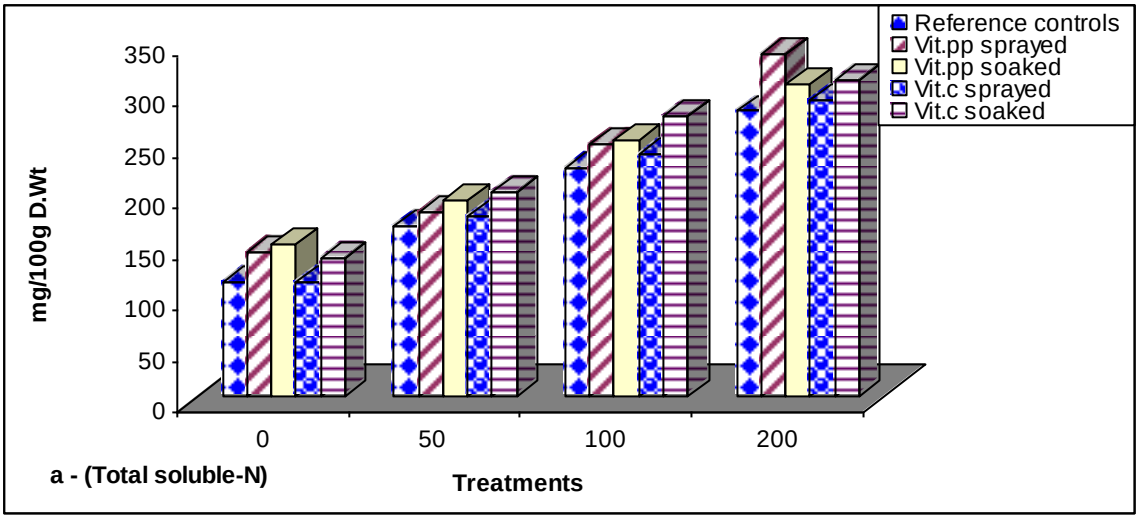
- Amino-N and proline:

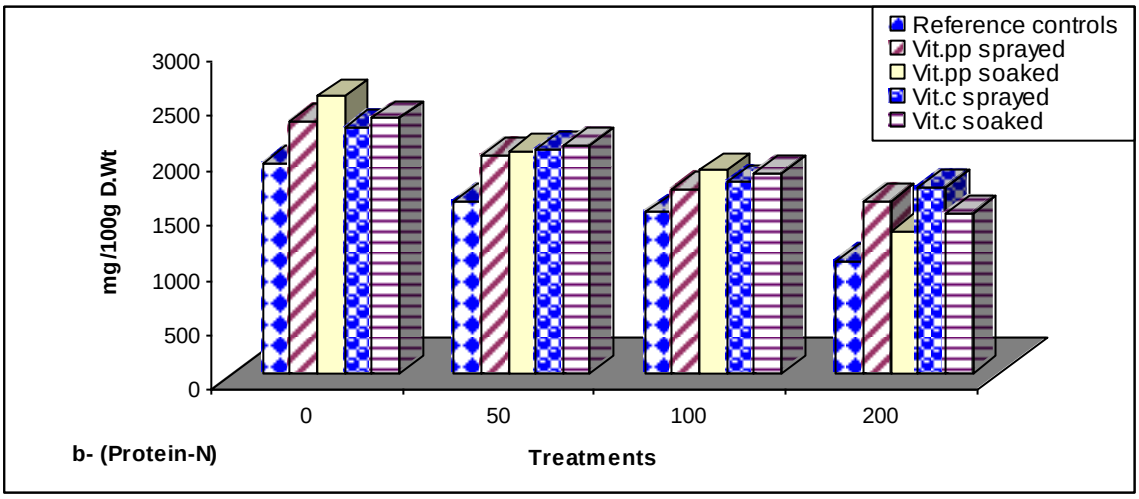
Salinity and/or vitamin (nicotinamide or ascorbic acid) treatments, grain soaking or plant spraying of *Zea mays* plants on the amino-N and proline contents are given in Table 7 and Fig. 5a-5b.

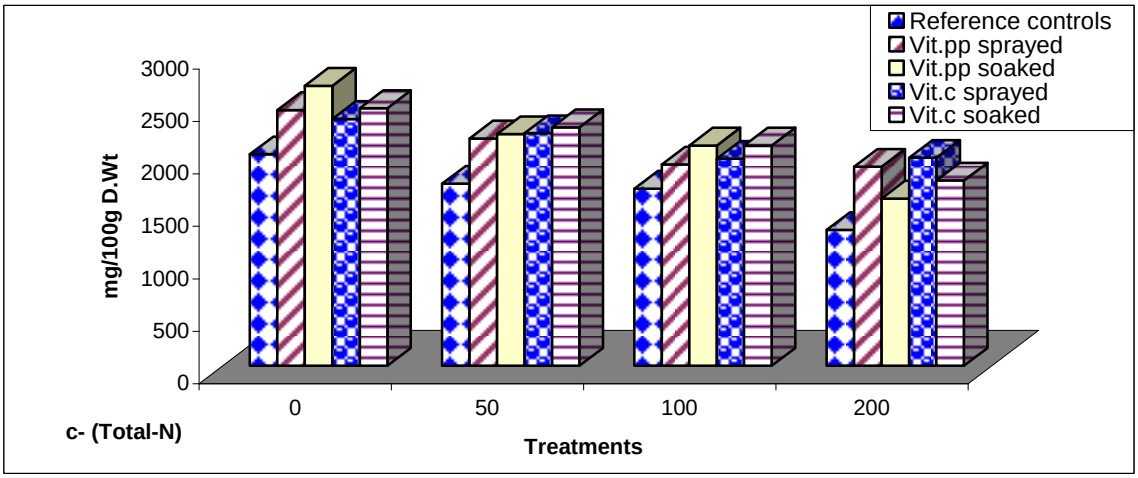
Table (6): Interactive effects of salinity and vitamins (nicotinamide or ascorbic acid) on nitrogen content (mg/100g dry weight) of shoots of *Zea mays* plants at 40 days from sowing. Values are expressed as mean of 3 independent samples.

Treatment		NaCl mM	Total soluble-N	%	Protein-N	%	Total-N	%
Reference controls		00	112	100.0	1904	100.0	2016	100.0
		50	168**	100.0	1568**	100.0	1736**	100.0
		100	224**	100.0	1464**	100.0	1688**	100.0
		200	280**	100.0	1014**	100.0	1294**	100.0
NaCl + 100 ppm Vit. pp	Sprayed	00	142**	126.7	2296**	120.5	2438**	120.9
		50	181**	107.7	1986**	126.6	2167**	124.8
		100	247**	110.2	1672**	114.2	1919**	113.6
		200	336**	120.0	1561**	153.9	1897**	146.5
	Soaked	00	149**	133.0	2520**	132.3	2669**	132.3
		50	192**	114.2	2016**	128.5	2208**	127.1
		100	252**	112.5	1848**	126.2	2100**	124.4
		200	307**	109.6	1288**	127.0	1595**	123.2
NaCl + 100 ppm Vit. C	Sprayed	00	112	100.0	2240**	117.6	2352**	116.6
		50	177**	105.3	2040**	130.1	2217**	127.7
		100	238**	106.2	1736**	118.5	1974**	116.9
		200	291**	103.9	1692**	166.8	1983**	153.2
	Soaked	00	136**	121.4	2320**	121.8	2456**	121.8
		50	201**	119.6	2072**	132.1	2273**	130.9
		100	275**	122.7	1825**	124.6	2100**	124.4
		200	311**	111.0	1456**	143.5	1767**	136.5
L.S.D. at 5 %			2.96		2.38		2.67	
L.S.D. at 1 %			3.83		3.09		3.46	

* Significant differences ** Highly significant differences as compared with reference controls.







Fig(4a-4c): Interactive effects of salinity and vitamins (nicotinamide or ascorbic acid) on nitrogen content (mg/100g dry weight) of shoots of *Zea mays* plants at 40 days from sowing. Values are expressed as mean of 3 independent samples.

The data clearly show a highly significant increase in the contents of both amino-N and proline in plant with increasing salt stress. The highest contents of both amino-N and proline (approximately 2-fold of the control plant) was found under the highest level of NaCl (200mM) as compared with plants growing without salinity treatment (control).

Vitamin treatments resulted in highly significant increases in amino-N with concomitant reductions in proline contents, whatever the level of salt stress used and the method of vitamin application. The increase of amino-N contents were ranged from 29.6% to 79.2% in salinized *Zea mays* plants treated with vitamins while the reduction in proline contents were ranged from 81.43% to 47.4% as compared with those of the reference controls.

Also it is clearly shown that, grain soaking method with ascorbic acid is more effective in reduction of proline contents and in increasing amino-N contents, as compared with other treatments of both vitamins.

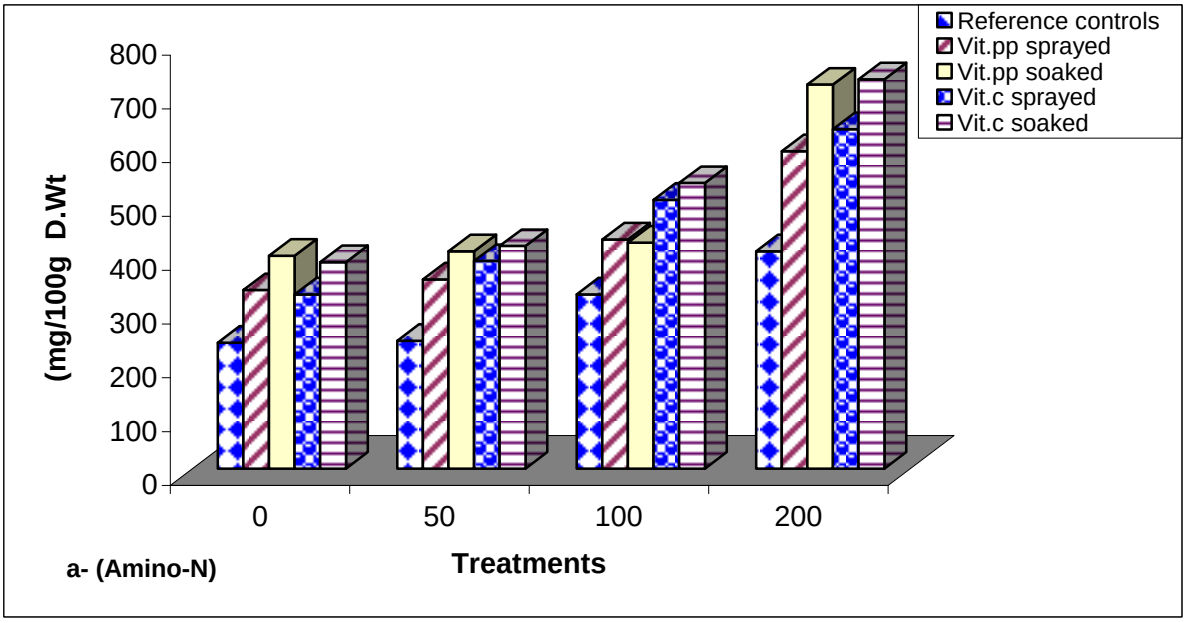
- Protein patterns:

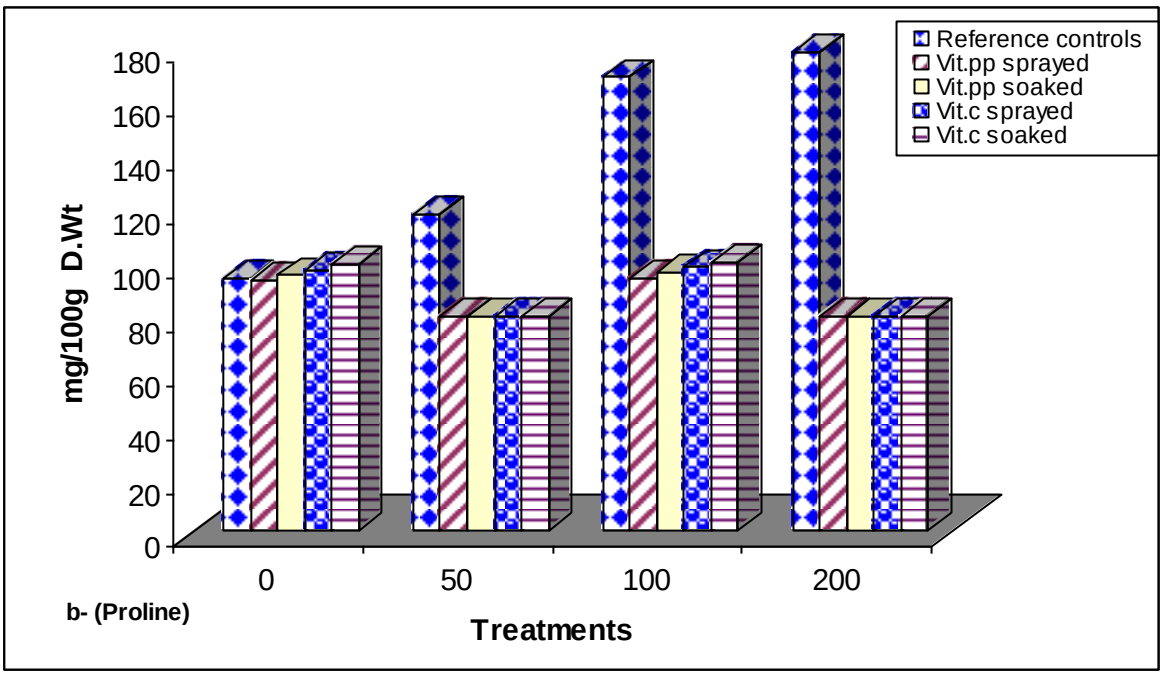
In the present work (plates 5-6 and Tables 8-9) three prominent types of modification are noted in the protein patterns of maize leaves; some protein were disappred, and certain of other proteins were selectively increased**,**

Table (7): Interactive effects of salinity and vitamins (nicotinamide or ascorbic acid) on amino-N and proline contents (mg/100g dry weight) of shoots of *Zea mays* plants at 40 days from sowing. Values are expressed as mean of 3 independent samples.

Treatment		NaCl mM	Amino-N	%	Proline	%
Reference controls		00	234	100.0	93.54	100.0
		50	238*	100.0	116.96**	100.0
		100	324**	100.0	167.88**	100.0
		200	404**	100.0	177.35**	100.0
NaCl + 100 ppm Vit. pp	Sprayed	00	332**	141.8	92.49**	98.87
		50	352**	147.8	79.20**	67.71
		100	426**	131.4	98.15**	58.46
		200	590**	146.0	104.20**	58.75
	Soaked	00	396**	169.2	60.39**	64.56
		50	404**	169.7	95.25**	81.43
		100	420**	129.6	97.09**	57.83
		200	714**	176.7	114.72**	64.68
NaCl + 100 ppm Vit. C	Sprayed	00	324**	138.4	71.57**	76.51
		50	386**	162.1	84.25**	71.87
		100	500**	154.3	95.25**	56.73
		200	631**	156.1	99.33**	56.00
	Soaked	00	384**	164.1	61.57**	65.82
		50	414**	173.9	66.17**	56.57
		100	531**	163.8	79.59**	47.40
		200	724**	179.2	101.57**	57.27
L.S.D. at 5 %			3.98		2.53	
L.S.D. at 1 %			5.15		3.28	

* Significant differences ** Highly significant differences as compared with reference controls.





Fig(5a-5b): Interactive effects of salinity and vitamins (nicotinamide or ascorbic acid) on amino-N and proline contents (mg/100g dry weight) of shoots of *Zea mays* plants at 40 days from sowing. Values are expressed as mean of 3 independent samples.

and synthesis of a new set of protein was induced, some of these responses were observed under vitamin and salinity treatements, while others were found to be specific to either vitamin or salinity.

It is clearly shown from Tables 8&9 that *Zea mays* plant was characterized by the presence of 11 common protein bands, their molecular weights are 149.51, 140.85, 128.95, 121.03, 83.58, 73.24, 61.44, 34.06, 28.49, 3.22, 1.36 KDa.

Non-Salinized control plants were characterized by the presense of 18 protein bands, they were ranged between 149.51 and 1.363 KDa. Salinity treatments induced the appearance of 4 new bands of molecular weights 69.37, 6.83, 4.51 and 2.67 KDa.

Application of nicotinamide (vitamin pp) either as shoot spraying or grain soaking caused the disappearance of the protein band (19.22 KDa) while grain soaking caused the disappearance of 25.10 KDa polypeptide. In addition, both vitamin pp treatments (shoot spraying or grain soaking) induced the new synthesis of the polypeptide of the molecular weight 15.86 KDa.

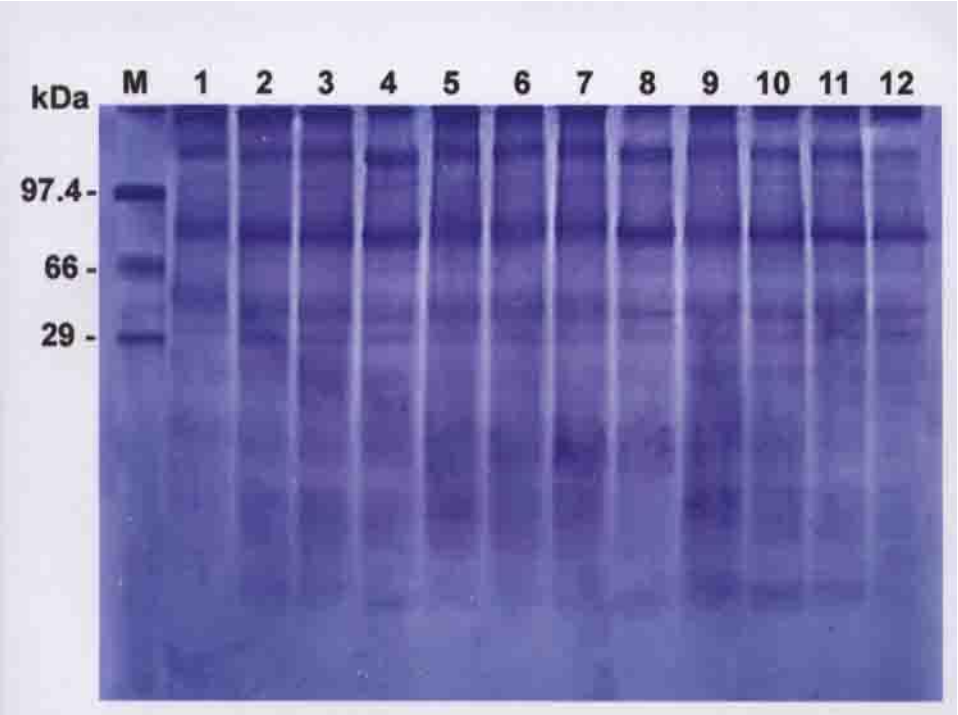


Plate (5): Electrograph of soluble protein pattern by one dimensional SDS-PAGE showing the change of protein bands (marked by arrowheads) in response to salinity and /or vitamins (vit.pp) of *Zea mays* plants at 40 days after sowing . Each lane contains equal amounts of protein extracted from *Zea mays* shoots .

Lane M Protein markers
Lane 1 control (H_2O)
Lane 2 50 mM NaCl
Lane 3 100 mM NaCl
Lane 4 200 mM NaCl
Lane 5 100ppm vit.pp spraying
Lane 6 50 mM NaCl + 100ppm vit.pp
Lane 7 100 mM NaCl +100ppm vit.pp
Lane 8 200 mM NaCl +100ppm vit.pp
Lane 9 100 ppm vit.pp soaking
Lane 10 50 mM NaCl+100 ppm vit.pp
Lane 11 100 mM NaCl +100ppm vit.pp
Lane 12 200 mM NaCl +100ppm vit.pp

Table (8): Relative area (%) of each protein band of *Zea mays* in response to salinity treatment alone or in combination with different levels of vitamin pp at 40 days after sowing.

Salinity					NaCl + 100 ppm Vit. pp							
					Sprayed				Soaked			
M.wt	00	50	100	200	00	50	100	200	00	50	100	200
149.51	16.0	10.7	8.06	6.1	14.1	12.2	14.4	7.94	12.2	10.1	13.2	14.4
140.85	5.79	3.34	3.91	2.54	5.24	6.23	3.12	2.44	3.89	1.7	1.05	2.87
128.95	6.77	2.9	4.76	6.57	6.39	5.29	5.13	5.68	5.17	3.01	3.43	2.78
121.03	3.59	6.31	4.98	6.45	4.22	4.59	5.33	6.78	5.63	3.36	3.96	2.95
112.33	2.72	3.12	4.04	5.14	4.69	3.05	4.17	4.71	3.1	2.38	2.87	2.26
97.84	3.19	2.56	1.98	2.46	3.23	2.82	1.98	-	1.94	2.42	1.39	1.8
83.58	4.68	4.2	5.42	3.65	4.64	6.23	4.77	4.88	5.14	4.42	3.62	4.43
79.10	8.92	13.6	12.4	16.9	7.36	7.84	9.22	17.2	10.6	17.1	14.4	11.4
73.24	1.33	1.76	1.45	1.51	2.77	2.76	2.21	2.1	2.68	2.63	2.81	2.62
69.37	-	0.289	0.147	0.322	0.291	0.436	0.725	0.657	0.086	1.61	1.49	2.37
61.44	1.67	1.35	1.53	0.902	0.269	1.33	0.588	0.387	2.68	0.902	1.33	1.99
34.06	0.43	4.52	2.08	1.94	1.32	1.24	0.392	1.19	1.45	1.71	3.59	2.19
28.49	0.098	0.97	4.14	2.44	0.594	0.439	0.786	1.11	1.96	1.99	1.51	0.719
25.104	0.114	0.169	1.62	1.34	0.069	0.248	1.2	0.169	-	-	-	-
19.223	0.158	0.048	0.134	0.441	-	-	-	-	-	-	-	-
15.86	-	-	-	-	0.308	0.194	0.337	1.09	0.423	0.877	0.138	0.299
10.1	1.02	0.972	0.624	0.308	1.92	1.37	2.28	3.1	0.897	2.22	0.803	0.53
6.86	-	0.427	0.233	0.211	3.17	2.58	2.2	1.68	0.335	0.733	0.289	-
4.51	-	0.177	0.096	0.393	2.3	0.617	2.7	0.554	1.11	-	0.053	0.188
3.22	0.704	0.845	1.07	1.53	1.51	2.43	1.44	0.345	2.55	1.7	0.731	1.43
2.673	-	1.01	0.75	0.942	0.684	1.15	1.38	0.952	1.41	1.67	2.45	-
2.17	1.51	1.17	1.02	0.705	-	-	0.277	1.15	3.5	2.01	2.48	3.45
1.363	1.35	1.82	2.3	3.17	0.517	1.05	1.91	3.84	1.72	4.82	4.19	4.69
1.01	-	-	-	-	-	-	-	-	-	-	-	-
Total no.of bands	18	22	22	22	21	21	22	21	21	20	21	19

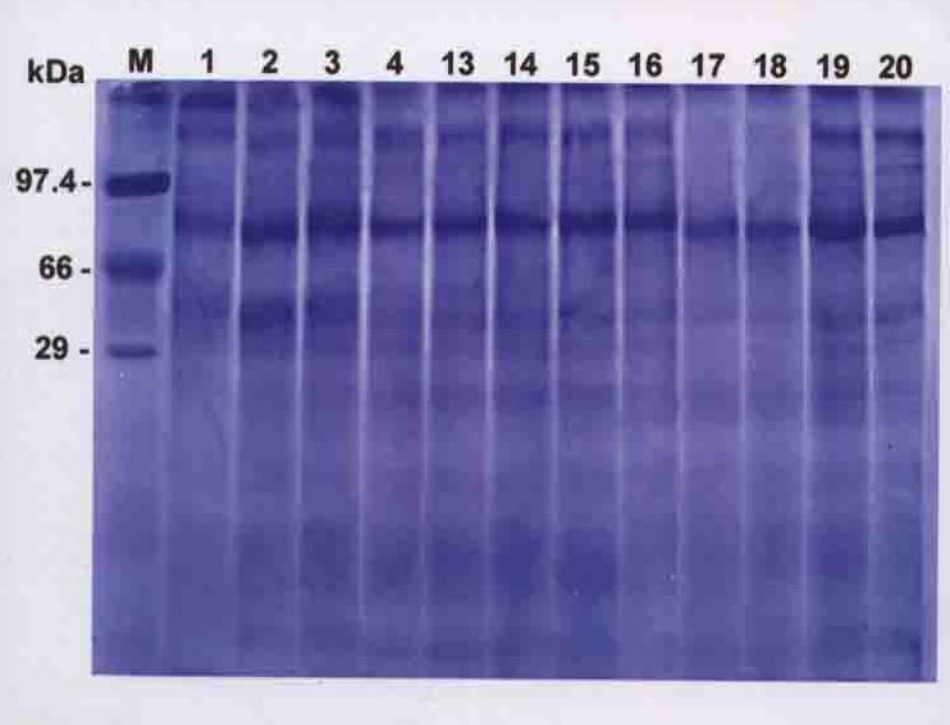


Plate (6): Electrograph of soluble protein pattern by one dimensional SDS-PAGE showing the change of protein bands (marked by arrowheads) in response to salinity and /or vitamins (vit.c) of Z*ea mays* plants at 40 days after sowing . Each lane contains equal amounts of protein extracted from *Zea mays* shoots .

Lane M Protein markers
Lane 1 control (H_2O)
Lane 2 50 mM NaCl
Lane 3 100 mM NaCl
Lane 4 200 mM NaCl
Lane 13 100ppm vit.c spraying
Lane 14 50 mM NaCl + 100ppm vit.**c**
Lane 15 100 mM NaCl +100ppm vit.c
Lane 16 200 mM NaCl +100ppm vit.c
Lane 17 100 ppm vit.c soaking
Lane 18 50 mM NaCl+100 ppm vit.**c**
Lane 19 100 mM NaCl +100ppm vit.**c**
Lane 20 200 mM NaCl +100ppm vit.c

Table (9): Relative area (%) of each protein band of *Zea mays* in response to salinity treatment alone or in combination with different levels of vitamin C at 40 days after sowing.

Salinity					NaCl + 100 ppm Vit. C							
					Sprayed				Soaked			
M. Wt	00	50	100	200	00	50	100	200	00	50	100	200
149.51	16.0	10.7	8.06	6.1	4.55	4.31	3.11	3.79	5.65	4.86	4.92	3.55
140.53	5.79	3.34	3.91	2.54	3.16	2.59	2.55	2.84	3.62	3.33	1.71	2.43
128.18	6.77	2.9	4.76	6.57	3.04	3.23	3.68	3.39	2.83	2.7	3.89	6.11
121.03	3.59	6.31	4.98	6.45	4.72	5.35	3.79	2.99	2.02	2.55	3.94	3.2
112.3	2.72	3.12	4.04	5.14	2.73	2.62	1.85	2.39	-	-	2.33	1.73
97.17	3.19	2.56	1.98	2.46	3.32	3.24	5.35	2.85	2.39	2.06	3.95	4.23
83.73	4.68	4.2	5.42	3.65	3.17	3.81	2.85	4.84	4.62	5.97	4.65	3.9
79.10	8.92	13.6	12.4	16.9	-	-	-	-	-	-	-	-
73.25	1.33	1.76	1.45	1.51	11.0	9.89	11.1	10.7	12.8	11.5	12	16.5
69.27	-	0.289	0.147	0.332	3.31	4.83	4.37	5.05	4.97	5.64	5.15	3.62
61.44	1.67	1.35	1.53	0.902	4.27	2.8	3.52	2.97	1.73	2.94	1.62	2.05
34.06	0.43	4.52	2.08	1.94	7.25	7.58	5.45	4.43	4.63	3.56	5.6	5.74
28.49	0.098	0.979	4.14	2.44	4.79	3.26	4.68	3.7	2.53	2.68	4.8	4.77
25.10	0.114	0.169	1.62	1.34	-	1.46	1.01	0.902	0.433	0.977	2.04	1.42
19.22	0.158	0.048	0.134	0.441	2.49	2.79	2.21	0.847	1.08	0.822	1.45	1.82
15.86	-	-	-	-	0.033	0.011	0.078	0.101	0.355	0.067	0.255	0.301
10.1	1.02	0.972	0.624	0.308	0.149	0.007	0.134	0.131	-	-	-	-
6.83	-	0.427	0.233	0.211	0.489	0.273	0.536	0.271	0.093	0.352	0.451	0.586
4.51	-	0.177	0.096	0.393	0.678	0.487	0.622	0.156	0.45	1.12	0.298	0.146
3.22	0.704	0.845	1.57	1.53	1.68	1.87	1.24	0.965	1.64	2.69	2.33	0.74
2.671	-	1.01	0.57	0.942	0.981	1.04	3.87	2.88	1.25	0.810	1.34	1.33
2.170	1.51	1.17	1.02	0.705	1.14	1.03	1.9	-	-	-	-	-
1.36	1.35	1.82	2.3	3.17	1.62	1.61	2.86	1.62	4.37	5.56	2.41	5.45
1.01	-	-	-	-	1.43	1.61	1.7	2.86	3.82	-	3.34	-
Total no. of bands	18	22	22	22	22	23	23	22	20	19	21	20

Vitamins pp treatment (spray or grain soaking) increased the intensities of the protein bands; 73.24 and 69.37 KDa in salinized *Zea mays* plants while grain soaking treatment increased the intensities of protein bands; 2.17 and 1.36 KDa. As compared with salinized plant.

Application of vitamin c (ascorbic acid) as spraying or grain soaking treatment induced the synthesis of 2 new protein bands of molecular weights 15.86 and 1.01 KDa while grain soaking treatment induced the disappearance of 2 protein bands of molecular weights 10.1 and 2.17 KDa. It is interesting to mention here that shoot spraying or grain soaking treatment highly increased the over expression of the protein bands having the molecular weight 73.25 KDa.

5- Protease and amylases enzymes activity:

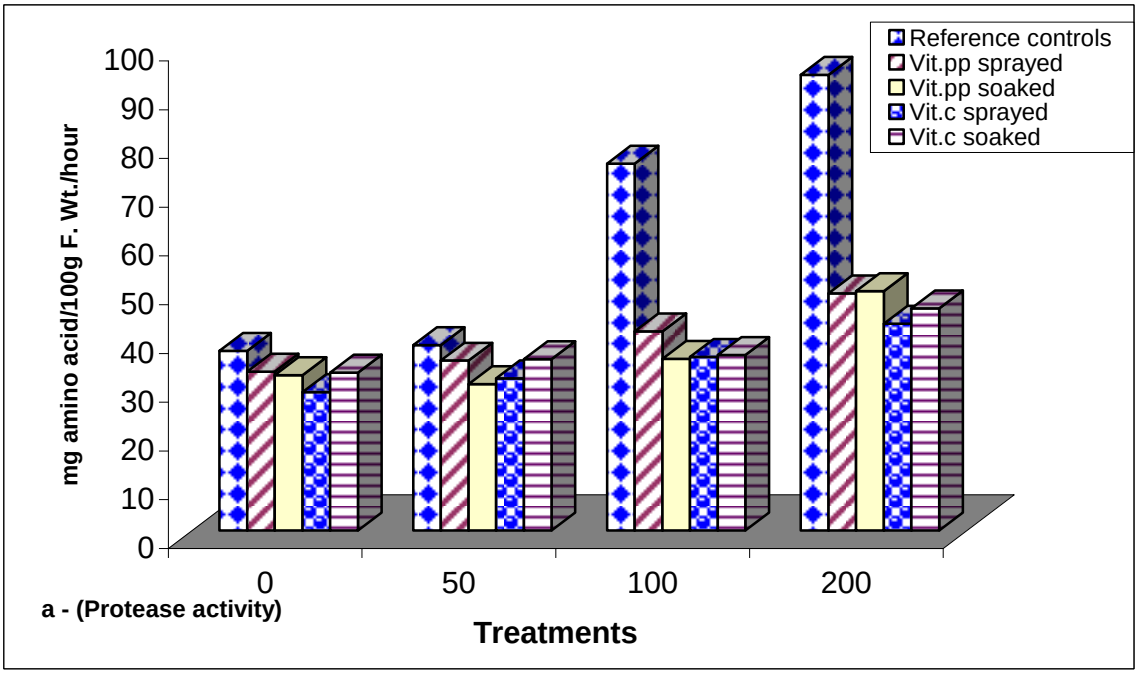
The changes in protease and amylases activeties in shoot of *Zea mays* plant affected by the different levels of NaCl and grain soaking or shoot spraying with either nicotinamide or ascorbic acid are represented in Table 10 and Fig. 6a-6b

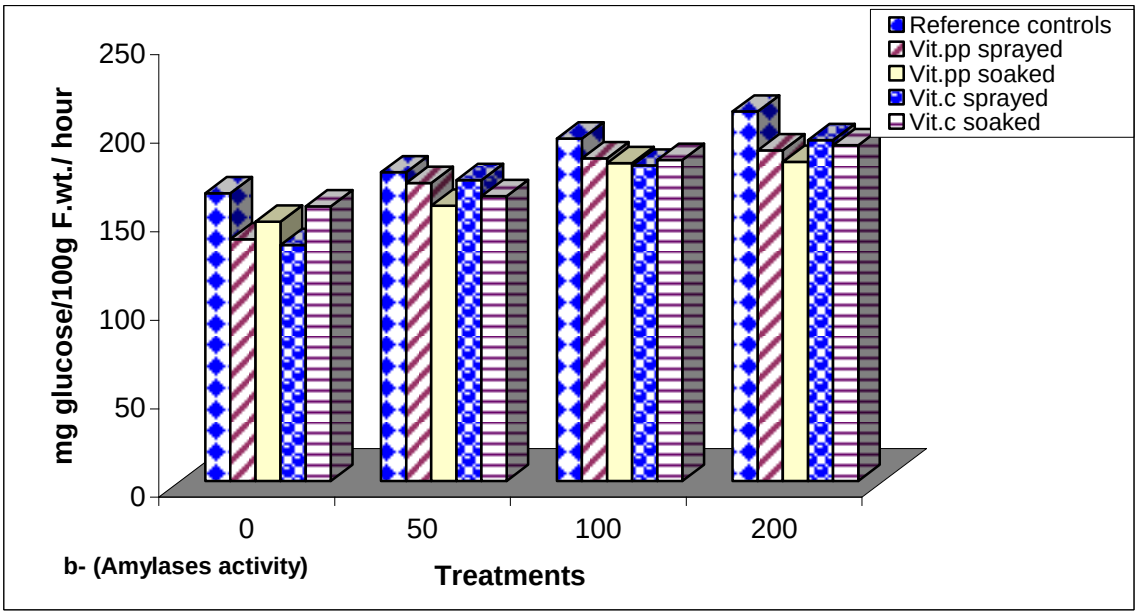
In relation to control levels the activity of protease and amylases enzymes showed, progressive highly significant increases with an increase in concentration of NaCl, except the lowest concentration of NaCl (50mM) which induced non-significant increase in protease activity.

Table (10): Interactive effects of salinity and vitamins (nicotinamide or ascorbic acid) on protease (mg amino-N/100 g F.Wt/hour) and amylases enzymes (mg glucose/100g F.Wt/hour) activity of shoots of *Zea mays* plants at 40 days from sowing. Values are expressed as mean of 3 independent samples.

Treatment		NaCl mM	Protease activity	%	Amylases activity	%
Reference controls		00	36.84	100.0	162.5	100.0
		50	37.98	100.0	174.3**	100.0
		100	75.26**	100.0	193.3**	100.0
		200	93.47**	100.0	208.6**	100.0
NaCl + 100 ppm Vit. pp	Sprayed	00	32.57	88.40	136.4**	83.93
		50	34.83	91.70	168.2**	96.50
		100	40.85**	54.27	182.1**	94.20
		200	48.62**	52.01	186.7**	89.49
	Soaked	00	31.84	86.42	146.4**	90.09
		50	30.01**	76.01	155.4**	89.15
		100	35.17**	46.69	179.4**	92.80
		200	49.08**	52.50	180.2**	86.38
NaCl + 100 ppm Vit. C	Sprayed	00	28.37**	77.0	133.2*	81.96
		50	31.21*	82.17	169.8**	97.41
		100	35.56**	47.24	178.1**	92.13
		200	42.39**	45.35	192.5**	92.27
	Soaked	00	32.36	87.83	155.1**	95.44
		50	35.14	92.52	160.8**	92.25
		100	35.99**	47.82	181.2**	93.74
		200	45.52**	48.70	189.6**	90.88
L.S.D. at 5 %			6.03		4.08	
L.S.D. at 1 %			7.81		5.28	

* Significant differences ** Highly significant differences as compared with reference controls.





Fig(6a-6b): Interactive effects of salinity and vitamins (nicotinamide or ascorbic acid) on protease and amylases enzymes activity of shoots of *Zea mays* plants at 40 days from sowing. Values are expressed as mean of 3 independent samples.

In general, application of vitamins (vit.pp or vit.c) by grain soaking or shoot spraying resulted in a highly significant decrease in the activity of protease and amylase enzymes, whatever the salinization level used when compared with the reference controls. The reduction in the protease activity of the salinized plants treated with either of the two vitamins was ranged from 92.52% to 45.35% and in amylase activity was ranged from 97.41% to 86.38% as compared with those of the reference controls.

6- Antioxidant enzymes:

The results presented in Table 11 and Fig. 7a-7c show the effect of various concentration of NaCl alone or in combination with nicotinamide or ascorbic acid (soaked or sprayed) on the activities of the antioxidant enzymes superoxide dismutase (SOD), catalase and peroxidase of the test *Zea mays* plant.

Activity levels of superoxide dismutase (SOD) and peroxidase showed a progressive significant increase with increasing concentration of NaCl, while the behavior of catalase enzyme showed an opposite response, as compared with those of the unsalinized plant.

Application of either of the two vitamins (vit.pp or vit.c) by grain soaking or shoot spraying caused, in most cases, highly significant decreases in the activities of both superoxide dismutase (SOD), and peroxidase enzymes, and highly significant increases in catalase activity as compared with those of the reference controls, the minimum percentage recorded of superoxide dismutase (SOD) in

salinized plants treated with vitamins were about 61.26% and 67.83% in case of (vit.pp) and 70.05% and 73.66% in case of (vit.c), while, the values of the minimum peroxidase activity were about 37.5% and 51.72% in case of (vit.pp) and 37.50% and 52.17% in case of (vit.c). On the other hand, the maximum percentage recorded of catalase activity were about 1200% and1600% in case of (vit.pp) and 1300% and 1400% in case of (vit.c) after spraying and soaking treatment, respectively.

7- Antioxidant substance (reduced glutathione):

The obtained results in Table 12 and Fig. 8a show the contents of reduced glutathione of test plant subjected to various treatments of salinity and vitamins (vit.pp or vit.c). The data clearly indicate that salt stress induced highly significant decreases in glutathione content as compared with that of the control unsalinized plants.

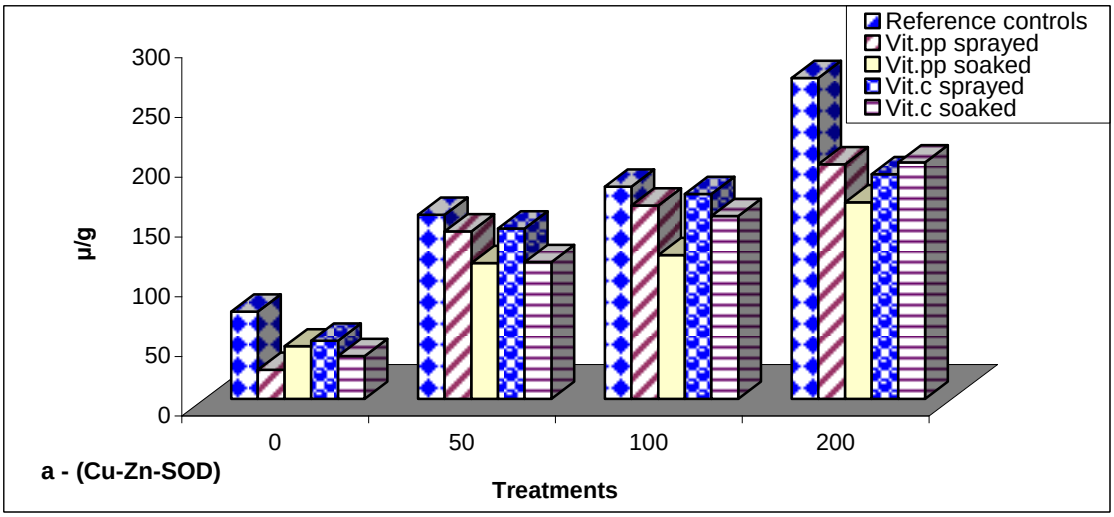
Application of vitamins (vit.pp or vit.c) by grain soaking or shoot spraying induced a highly significant increase in glutathione contents with all salinity levels used, except in case of plants sprayed with ascorbic acid and irrigated with 200 mM NaCl and plants resulted from grain soaking in ascorbic acid and irrigated with 100 mM NaCl, where the glutathione values are non-significant as compared with those of the reference controls.

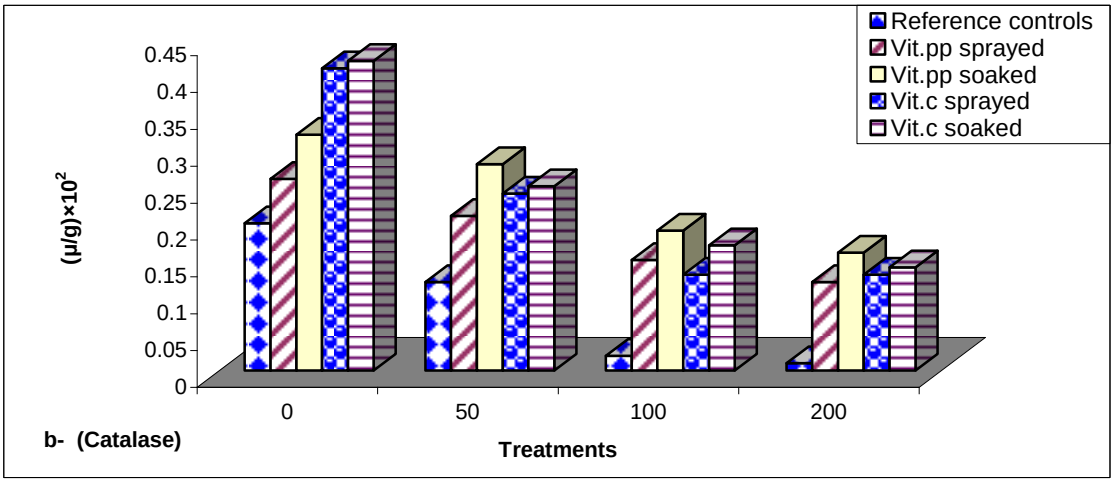
The maximum values of glutathione contents were about 136.13% and 122.2% in case of salinized plants treated with vit.c as compared with those of the reference controls, respectively. This indicated that vit.c is more effective in alleviating the adverse effect salinity by producing the higher levels of reduced glutathione

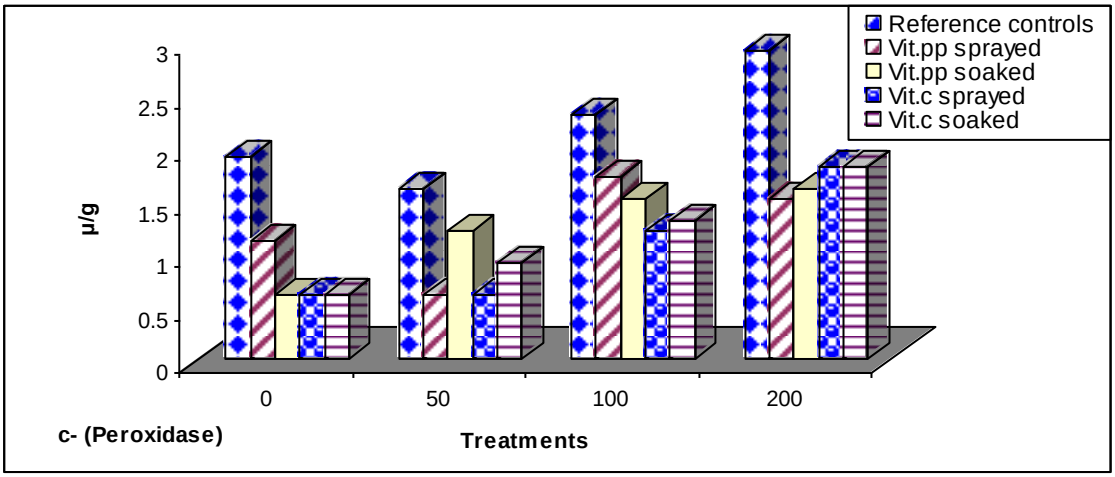
Table (11): Interactive effects of salinity and vitamins (nicotinamide or ascorbic acid) on antioxidant enzymes of shoots of *Zea mays* plants at 40 days from sowing. Values are expressed as mean of 3 independent samples.

Treatment		NaCl mM	Cu-ZnSOD(µ/g)	%	Catalase (µ/g) ×10^2	%	Peroxidase (µ/g)	%
Reference controls		00	73	100.0	0.2	100.0	1.9	100.0
		50	154**	100.0	0.12**	100.0	1.6	100.0
		100	177.5**	100.0	0.02**	100.0	2.3	100.0
		200	268.5**	100.0	0.01**	100.0	2.9**	100.0
NaCl + 100 ppm Vit. pp	Sprayed	00	24.2**	33.15	0.26*	130	1.1**	57.89
		50	140.0**	90.90	0.21**	175	0.6**	37.50
		100	161.8**	91.15	0.15**	750	1.7*	73.91
		200	196.2**	73.07	0.12**	1200	1.5**	51.72
	Soaked	00	43.9**	60.13	0.32**	160	0.6**	31.57
		50	113.6**	73.76	0.28**	133	1.2	75.00
		100	120.4**	67.83	0.19**	950	1.5**	65.21
		200	164.5**	61.26	0.16**	1600	1.6**	55.17
NaCl + 100 ppm Vit. C	Sprayed	00	48.6**	66.50	0.41**	205	0.6**	31.57
		50	142.4**	92.46	0.24**	200	0.6**	37.50
		100	171.5**	96.61	0.13**	650	1.2**	52.17
		200	188.1**	70.05	0.13**	1300	1.8**	62.06
	Soaked	00	35.7**	48.90	0.42**	210	0.6**	31.57
		50	114.5**	74.38	0.25**	208.3	0.9**	56.25
		100	153.0**	86.19	0.17**	850	1.3**	56.52
		200	197.8**	73.66	0.14**	1400	1.8**	62.06
L.S.D. at 5 %			5.76		0.05		0.51	
L.S.D. at 1 %			7.45		0.07		0.67	

* Significant differences ** Highly significant differences as compared with reference controls.





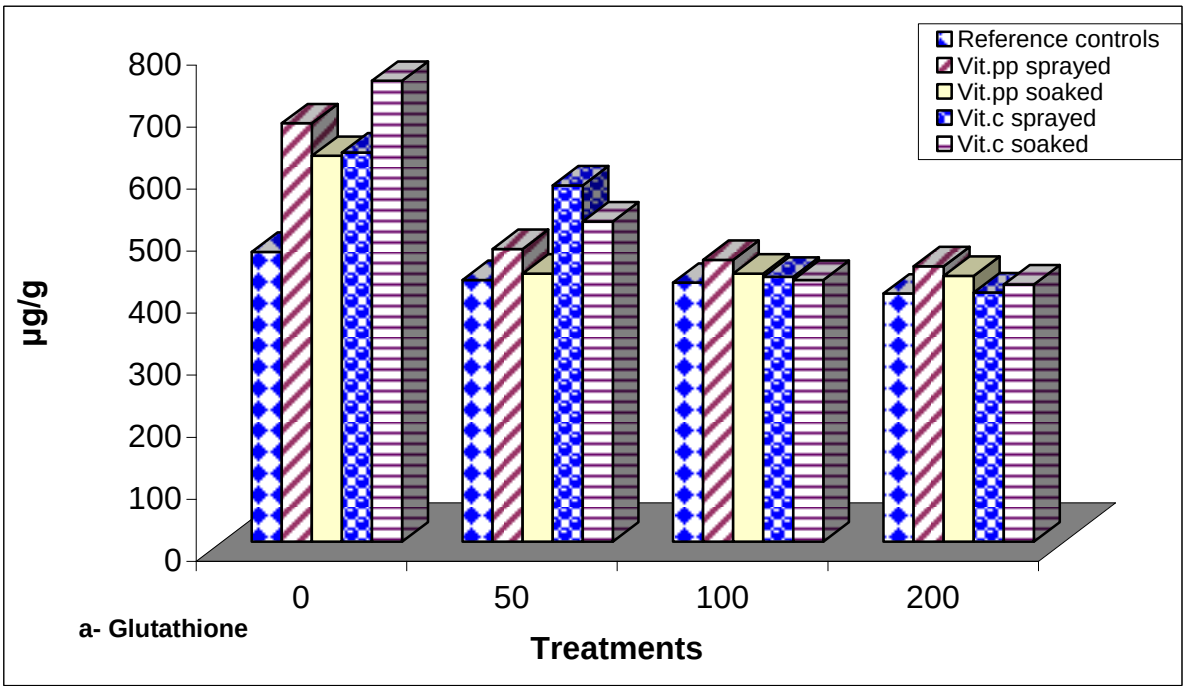


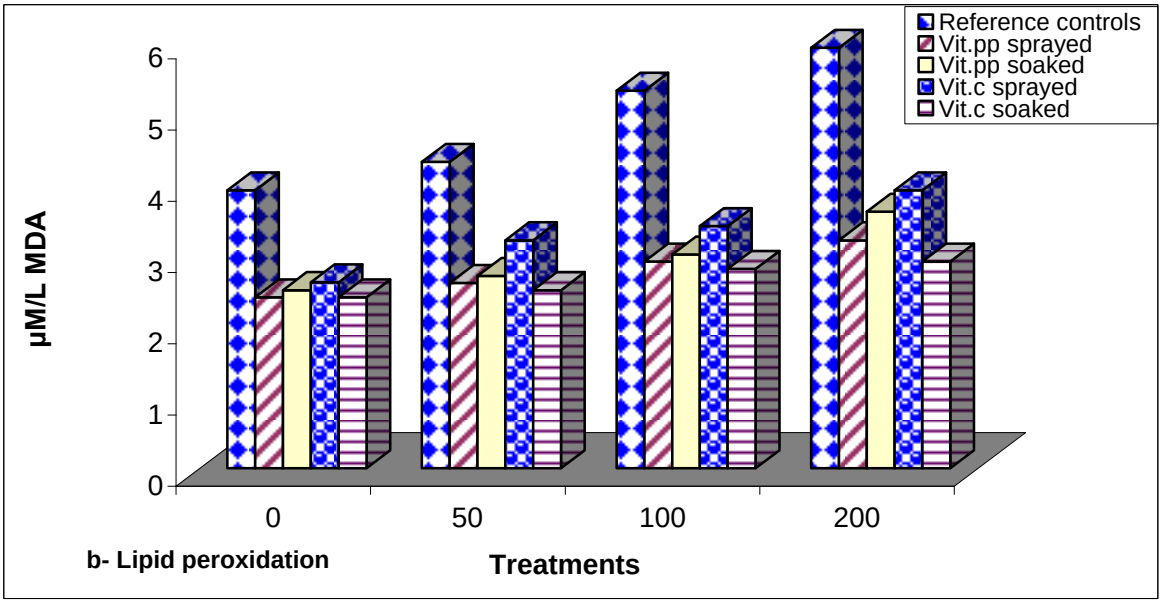
Fig(7a-7c): Interactive effects of salinity and vitamins (nicotinamide or ascorbic acid) on antioxidant enzymes of shoots of *Zea mays* plants at 40 days from sowing. Values are expressed as mean of 3 independent samples.

Table (12): Interactive effects of salinity and vitamins (nicotinamide or ascorbic acid) on reduced glutathione and malondilaldehyde contents in shoots of *Zea mays* plants at 40 days from sowing. Values are expressed as mean of 3 independent samples.

Treatment		NaCl mM	Glutathione (µg/g)	%	Lipid- peroxidation- MDA (µM/L)	%
Reference controls		00	467	100.0	3.9	100.0
		50	422**	100.0	4.3	100.0
		100	417.5**	100.0	5.3**	100.0
		200	400.0**	100.0	5.9**	100.0
NaCl + 100 ppm Vit. pp	Sprayed	00	674.5*	144.43	2.4	61.53
		50	472**	111.84	2.6**	60.65
		100	454.5**	108.86	2.9**	54.72
		200	444**	111.0	3.2**	54.23
	Soaked	00	622**	133.19	2.5**	64.10
		50	432**	102.36	2.7**	62.79
		100	432**	103.47	3.0**	56.60
		200	428.5**	107.12	3.6**	61.01
NaCl + 100 ppm Vit. C	Sprayed	00	627.5**	134.36	2.61	66.92
		50	574.5**	136.13	3.2**	74.41
		100	427**	102.2	3.4**	64.15
		200	402	100.5	3.9**	66.10
	Soaked	00	743**	159.1	2.4**	61.53
		50	516**	122.2	2.5**	58.13
		100	422	101.07	2.8**	52.83
		200	414.5**	103.62	2.9**	49.15
L.S.D. at 5 %			6.80		0.55	
L.S.D. at 1 %			8.80		0.71	

* Significant differences ** Highly significant differences as compared with reference controls.





Fig(8a-8b): Interactive effects of salinity and vitamins (nicotinamide or ascorbic acid) on reduced glutathione and malondilaldehyde contents in shoots of *Zea mays* plants at 40 days from sowing. Values are expressed as mean of 3 independent samples.

8- Lipid peroxidation (MAD):

The obtained resulted in Table 12 and Fig. 8b show the lipid peroxidation as indicated by the accumulation of malondialdehyde (MDA) of test plant subjected to various treatments of salinity and vitamins (vit.pp or vit.c). The data clearly indicate that salt stress induced a highly significant increase in lipid peroxidation (MDA content).

Application of vitamins (vit.pp or vit.c) either by grain soaking or shoot spraying induced a highly significant decrease in lipid peroxidation (MDA content) in salinized Zea mays plants as compared with those of the reference controls. It is interesting to mention here that the most effective treatment decreasing the lipid peroxidation as indicated by MDA accumulation is grain soaking in vitamin c followed by spraying with vitamin pp.

9- Contents of inorganic cations:

Considering the depressive effects of salinity and the promoting effects of vitamin (nicotinamide or ascorbic acid) treatements on plant metabolism and growth activities, particular attention was focused on the role of the two applied vitamins in modifying salt-stress induced changes in the content of monovalent (Na^+, K^+) and divalent (Ca^{++}, Mg^{++}) cations in the shoot of the maize plant, (Table 13 and Fig. 9a-9d).

- Sodium:

The content of sodium shows a marked and progressive increase in the shoot system, with rising salinity levels compared with unsalinized plant (control). At the highest salinity level

(200mM NaCl) used, the accumulation of Na^+ was about 2.8 fold compared with that of the control plant.

Vitamin treatments caused a decrease in the accumulation of sodium whatever the salinization level used and the method of vitamin application, the depressive effect of vitamin on the accumulation of Na was more obvious in case of ascorbic acid treatments.

- Potassium:

The effect of salt stress on K+ content in the test plant (Table 13 and Fig. 9b) reveals that, salinization treatement failed to stimulate potassium accumulation with the rise of NaCl supply. It is clearly shown that the inhibitory effects of NaCl treatements on the accumulation of potassium were elevated with the rise of NaCl supply as compared with the unsalinized plant (control).

In general, vitamin (nicotinamide or ascorbic acid) treatments induced a high significant stimulation in the accumulation of potassium, in comparison with those of plants subjected only to the corresponding levels of NaCl (reference controls).

- Calcium:

Results shown in Table 13 and Fig. 9c reveal that contents of Ca++ in test plant highly significantly decreased with the rise of salinization level.Treatments with one of the two vitamins (vit.pp or vit.c) resulted in highly significant increases in Ca^{++} contents in salinized *Zea mays* plants as compared with those of the reference controls

Table (13): Interactive effects of salinity and vitamins (nicotinamide or ascorbic acid) on Na^+, K^+, Ca^{++} and Mg^{++} (mg/g dry weight) of shoots of *Zea mays* plants at 40 days from sowing. Values are expressed as mean of 3 independent samples.

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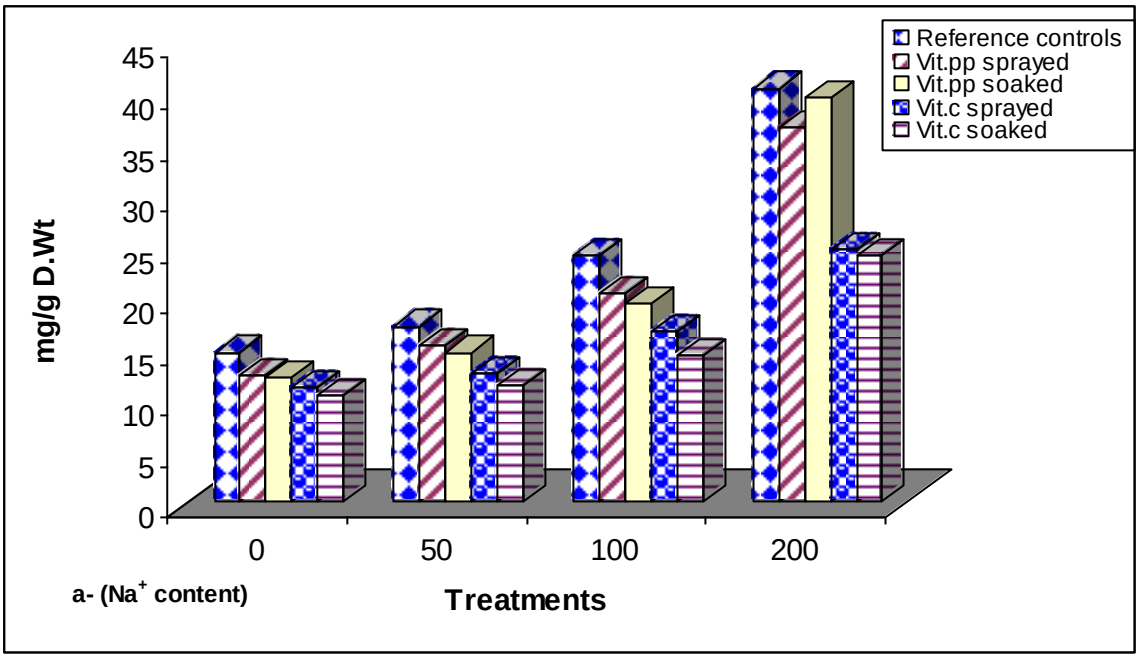
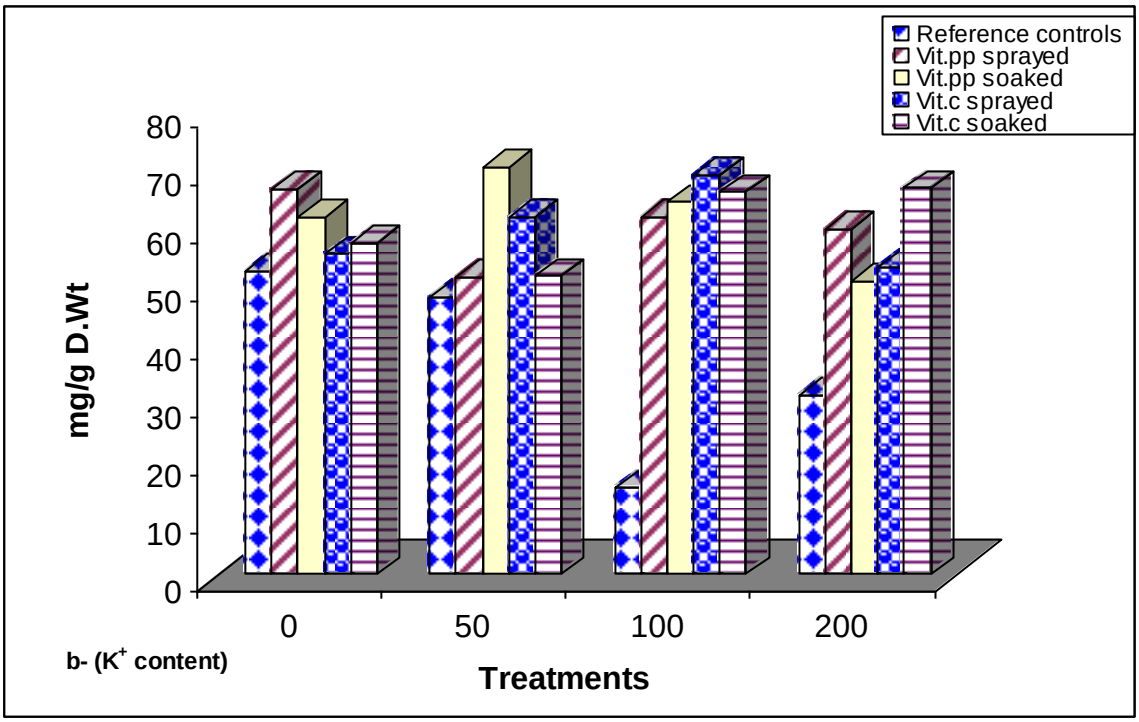
Treatment		NaCl mM	Mineral content (mg/g dry weight)							
			Na^+	%	K^+	%	Ca^{++}	%	Mg^{++}	%
Reference controls		00	14.6	100.0	52.13	100.0	9.03	100.0	7.69	100.0
		50	17.1**	100.0	47.68**	100.0	8.01*	100.0	6.80*	100.0
		100	24.0**	100.0	14.86**	100.0	7.2**	100.0	6.63**	100.0
		200	40.4**	100.0	30.89**	100.0	7.2**	100.0	5.80**	100.0
NaCl + 100 ppm Vit. pp	Sprayed	00	12.3**	84.2	66.32**	127.2	9.84	108.9	8.55*	111.1
		50	15.3**	89.4	51.16**	107.2	9.14**	114.1	7.98**	117.3
		100	20.3**	84.5	61.43**	146.5	8.54**	118.6	7.63**	115.0
		200	36.6**	90.5	59.43**	192.3	8.58**	119.1	6.60*	113.7
	Soaked	00	12.1**	82.8	61.48**	117.9	9.48	104.9	9.68**	125.8
		50	14.6**	85.3	70.16**	147.1	9.77**	121.9	8.19**	120.4
		100	19.4**	80.8	64.16**	153.2	8.88**	123.3	7.65**	115.3
		200	39.5**	97.7	50.49**	163.4	10.81**	150.1	6.88**	118.6
NaCl + 100 ppm Vit. C	Sprayed	00	11.1**	76.0	55.16**	105.8	9.25	102.4	8.50*	110.5
		50	12.5**	73.0	61.59**	129.1	9.82**	122.5	7.86**	115.5
		100	16.6**	69.1	68.71**	164.1	9.90**	137.5	7.04	106.1
		200	24.7**	61.1	52.83**	171.0	10.31**	143.1	6.34	109.3
	Soaked	00	10.4**	71.2	56.98**	109.3	9.98*	110.5	8.47*	110.1
		50	11.3**	66.0	51.33**	107.6	9.67**	120.7	7.10	104.4
		100	14.3**	59.5	65.78**	135.6	8.90**	123.6	7.29	109.9
		200	24.0**	59.4	66.46**	215.1	9.58**	133.0	7.86**	135.5
L.S.D. at 5 %			1.77		1.87		1.84		0.77	
L.S.D. at 1 %			2.29		2.42		1.08		1.00	

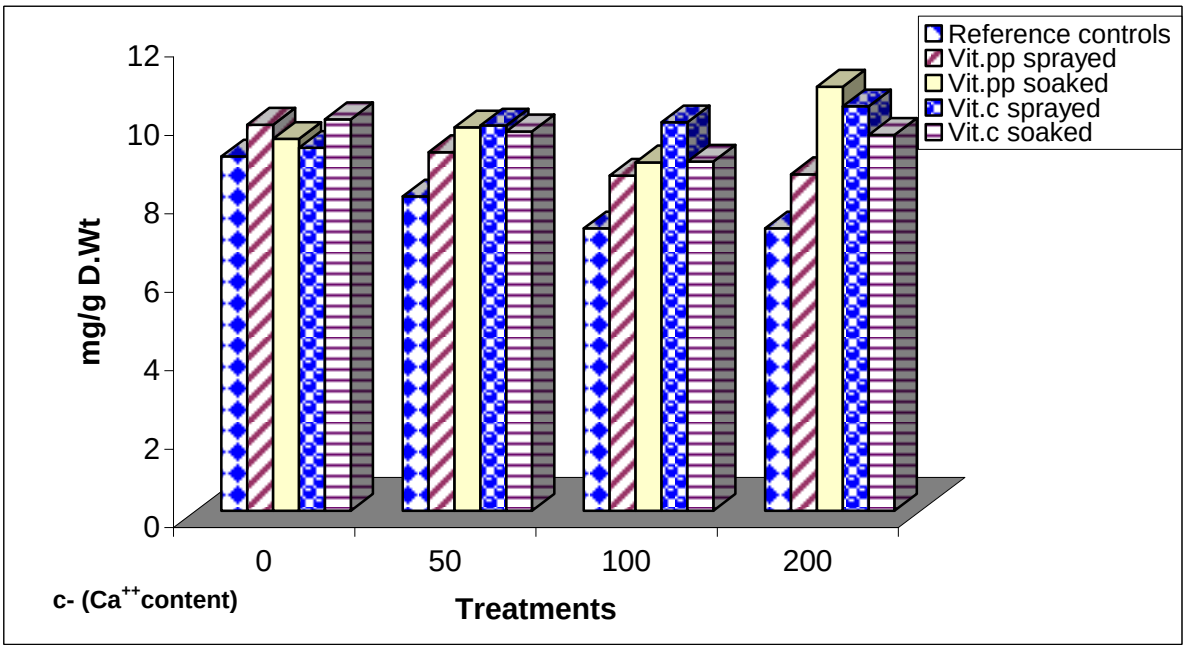
* Significant differences ** Highly significant differences as compared with reference controls.

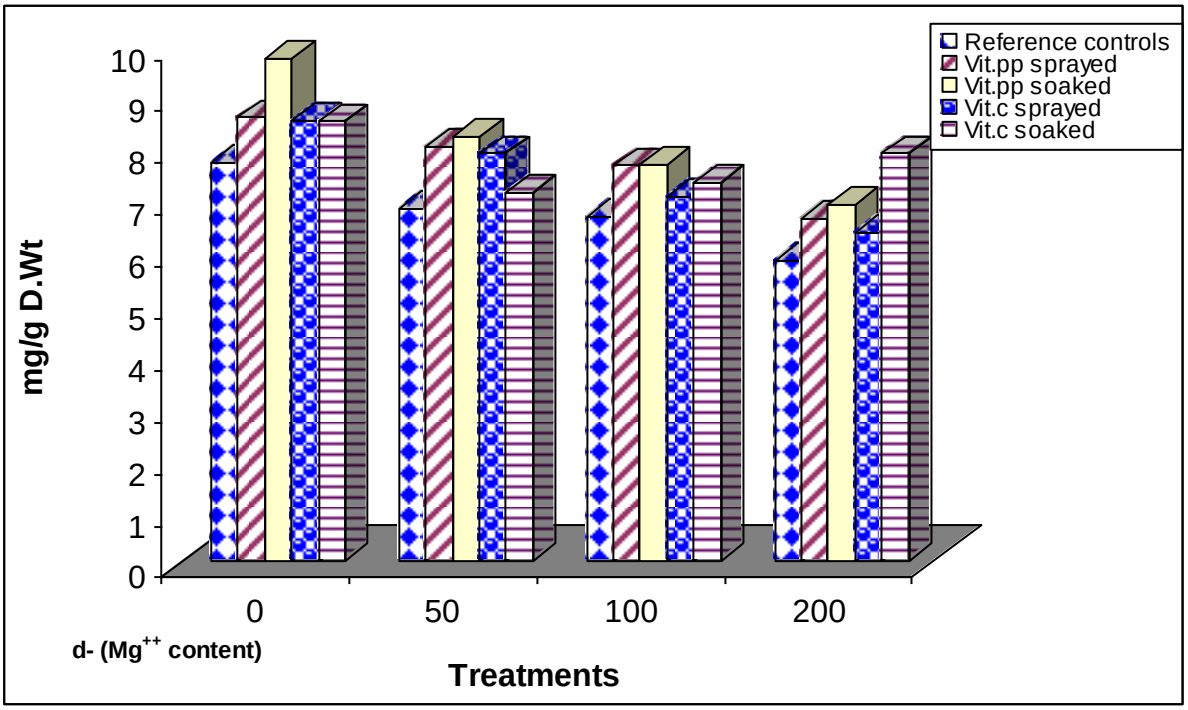


a- (Na^+ content)



b- (K^+ content)





Fig(9a-9d): Interactive effects of salinity and vitamins (nicotinamide or ascorbic acid) on Na^{+}, K^{+}, Ca^{++} and Mg^{++} (mg/g dry weight) of shoots of *Zea mays* plants at 40 days from sowing. Values are expressed as mean of 3 independent samples.

- Magnesium:

The data given in Table 13 and Fig. 9d show that Mg^{++} contents in maize plants were highly significantly lowered with the rise of salinity level especially at the highest levels (100, 200 mM NaCl), as compared with the unsalinized plants (control).

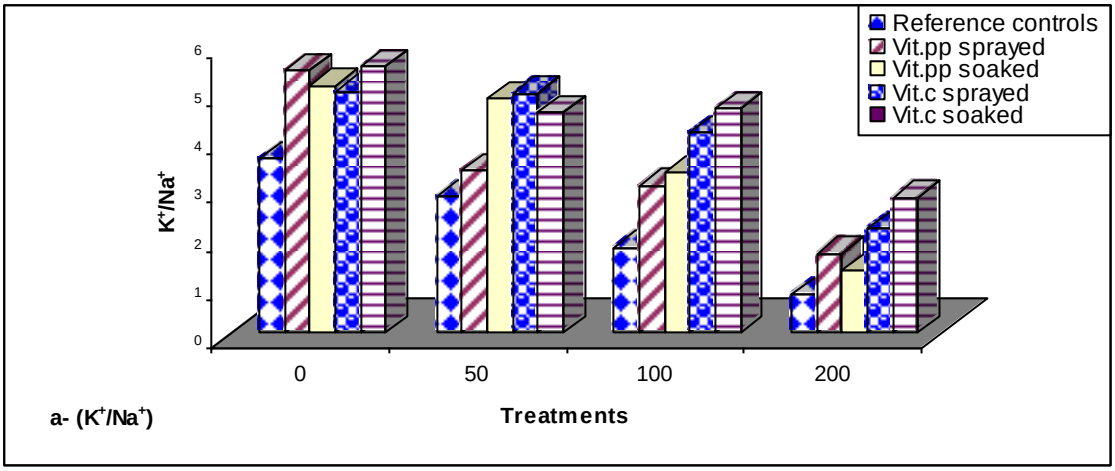
Grain soaking or spraying with one of the two vitamins (nicotinamide or ascorbic acid) induced highly significant increases in Mg++ contents in shoots of salinized *Zea mays* plants, whatever the salinization level used except when plant were sprayed with vit.c, at level 100, 200 mM NaCl or when grains were soaked in vit.c at level 50, 100 mM NaCl, non-significant increases were observed as compared with those of the reference controls.

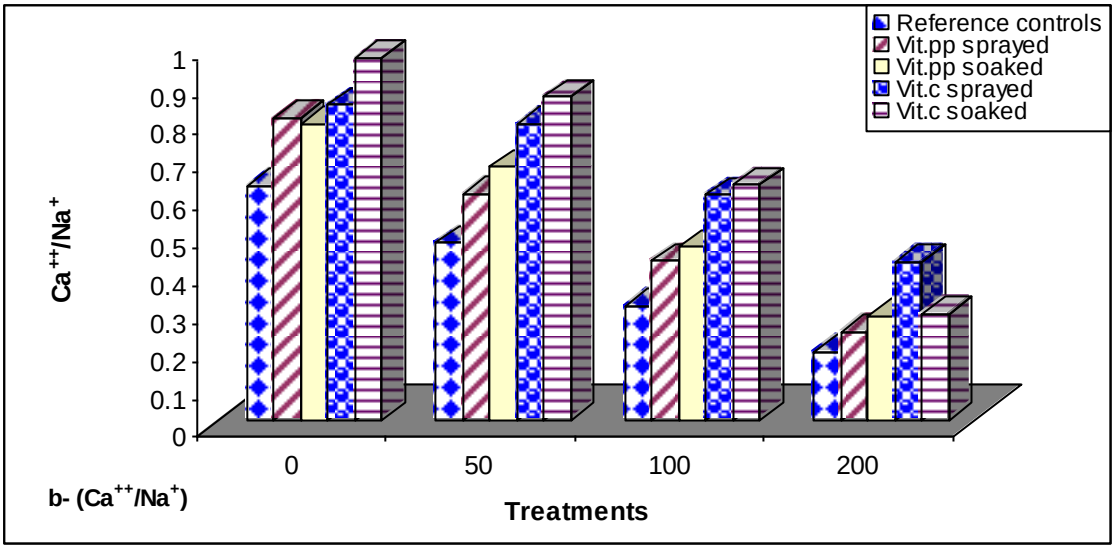
10- Ratios of K^+/Na^+, Ca^{+2}/Na^+ and Mg^{+2}/Na^+:

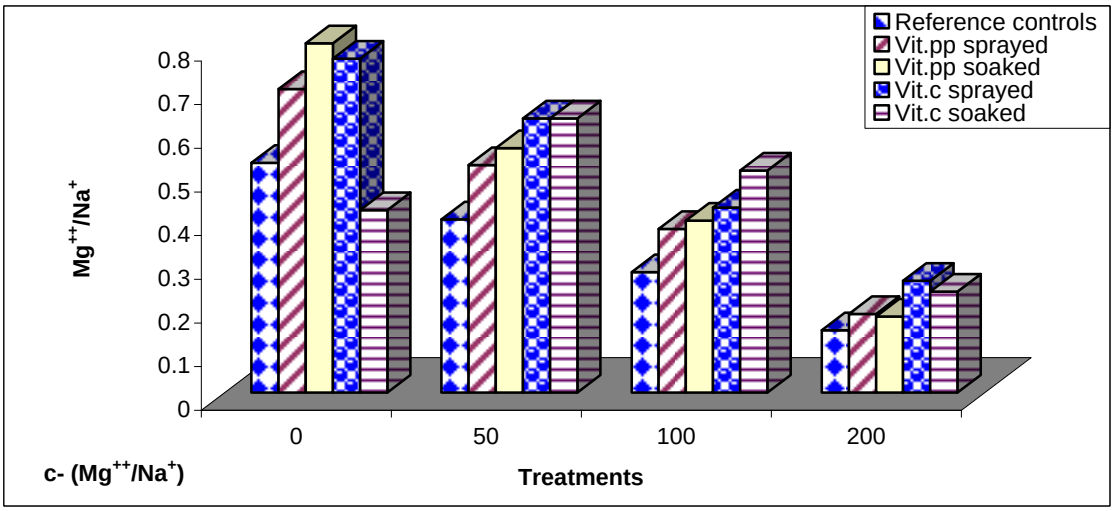
The ions relation in *Zea mays* plant as affected by salt stress and vitamin treatments are summarized in Table 14 and Fig. 10a-10c, the data obtained herein show that a high selectivity for Na^+ uptake over Ca^{++}, Mg^{++} and K^+ uptake with the increase of salinity level, irrespective of the vitamin treatments. However, there was a beneficial effect of shoot spraying and grain soaking in either nicotinamide or ascorbic acid which was generally reflected in the reduction of Na^+ accumulation and/or the increase in K^+, Ca^{++} and Mg^{++} ions which in turn reflected in the increase in K/Na, Ca/Na and Mg/Na ratios as compared with those of the corresponding control plants.

Table (14): Interactive effects of salinity and vitamins (nicotinamide or ascorbic acid) on K^+/Na^+, Ca^{++}/Na^+ and Mg^{++}/Na^+ of shoots of *Zea mays* plants at 40 days from sowing. Values are expressed as mean of 3 independent samples.

Treatment		NaCl mM	K^+/Na^+	Ca^{++}/Na^+	Mg^{++}/Na^+
Reference controls		00	3.57	0.618	0.526
		50	2.78	0.468	0.397
		100	1.74	0.300	0.276
		200	0.764	0.178	0.143
NaCl + 100 ppm Vit. pp	Sprayed	00	5.39	0.800	0.695
		50	3.34	0.597	0.521
		100	3.02	0.420	0.375
		200	1.62	0.234	0.180
	Soaked	00	5.08	0.783	0.800
		50	4.80	0.669	0.560
		100	3.30	0.457	0.394
		200	1.27	0.273	0.174
NaCl + 100 ppm Vit. C	Sprayed	00	4.96	0.833	0.765
		50	4.92	0.785	0.628
		100	4.13	0.596	0.424
		200	2.13	0.417	0.256
	Soaked	00	5.47	0.959	0.418
		50	4.54	0.855	0.628
		100	4.6	0.622	0.509
		200	2.77	0.281	0.231







Fig(10a-10c): Interactive effects of salinity and vitamins (nicotinamide or ascorbic acid) on K^+/Na^+, Ca^{++}/Na^+ and Mg^{++}/Na^+ of shoots of *Zea mays* plants at 40 days from sowing. Values are expressed as mean of 3 independent samples.