RESULTS

A significant reduction in the rate of emergence of seeds was observed at the end of 48 hours of germination under 0.5% of salt (Table 1). However, the final percentage of germination was not affected. Salt at 1.0% level also significantly reduced only the rate of emergance of seeds. However, salt at 1.5% level markedly reduced the rate of emergance as well as the final percentage of germination and at 2.0% level it completely inhibited the germination of seeds.

The growth of root and shoot systems of 5-day old seedlings was found enhanced by lower concentrations of salt such as 0.05, 0.1 and 0.2% (Table 2). However, significant increase in the growth of root and shoot systems was observed only at 0.1% level of salt. Salt at 0.5% slightly increased the growth of root system and it significantly reduced the growth of shoot system. The growth of root and shoot systems was significantly reduced by the salt at 1.0 and 1.5% levels.

Soaking of seeds in water for 2, 4 and 8 hours significantly increased the rate of emergence of seeds especially at the end of 48 hours of germination (Table 3). However, soaking of seeds for 4 hours resulted in cent per cent germination by the end of 72 hours. Hence the pre-

Table 1. Effect of different concentrations of salt (NaCl) on germination of seeds of paddy.

Concentration of NaCl %	Duration of germination in hours				
	24	48	72	96	120
Control	0.0	98.5	99.9	100.0	100.0
0.05	0.0	99.0	99.0	100.0	100.0
0.10	0.0	99.0	99.5	100.0	100.0
0.20	0.0	98.0	99.0	99.5	100.0
0.50	0.0	87.0	99.0	99.5	99.5
1.00	0.0	39.0**	66.5**	89.3**	98.0*
1.50	0.0	3.0**	30.5**	45.0**	72.5**
2.00	0.0	0.0	0.0	0.0	0.0
LSD at 1% level	-	5.47	5.89	7.24	2.23
LSD at 5% level	-	3.93	4.23	5.20	1.60

* Significant at 5% level.

** Significant at 1% level.

Table 2. Effect of different concentrations of salt (NaCl) on growth of 5-day-old seedlings of paddy.

Concentration of NaCl %	Length of root in millimeters	Length of shoot in millimeters
Control	60.32	45.96
0.05	61.50	46.15
0.1	67.80**	49.35
0.2	66.25*	47.50
0.5	63.10	38.75
1.0	32.30	18.75
1.5	4.85	8.95
2.0	0.00	0.00
LSD at 1% level	6.73	5.89
LSD at 5% level	4.99	4.37

* Significant at 5% level.

** Significant at 1% level.

Table 3. Effect of different durations of soaking in distilled water on germination of seeds.

Duration of soaking (hours)	Duration of germination in hours				
	24	48	72	96	120
Control	0.0	85.0	91.0	97.0	98.0
2	0.0	91.0**	95.0*	98.0	99.5**
4	0.0	99.5**	100.0**	100.0**	100.0**
8	0.0	99.0**	99.5**	99.5*	99.5**
LSD at 1% level	-	4.22	5.28	2.81	1.73
LSD at 5% level	-	2.79	3.49	1.85	1.14

* Significant at 5% level.

** Significant at 1% level.

sowing soaking treatment of seeds with various chemicals was carried out for 4 hours.

Effect of succinic acid on germination of seeds and growth of seedlings under different levels of salt

Pre-sowing soaking treatment of seeds with 5, 10 and 20 mg/l concentrations of succinic acid brought about an increase in the rate of emergance (Table 4). However, the final percentage of germination was not affected by the treatment of seeds with succinic acid. Succinic acid at a concentration of 5 mg/l significantly increased the rate of emergance and final percentage of germination of seeds at 1.5% level of salt. Seeds treated with 5 mg/l succinic acid showed 14% germination at 2.0% level of salt at the end of 120 hours.

Growth of seedlings was not significantly affected by succinic acid tried at all concentrations (Table 5). The growth of seedlings in presence of salt was slightly enhanced by succinic acid at a concentration of 5 mg/l.

Effect of CCC on germination of seeds and growth of seedlings under different levels of salt

Treatment of seeds with CCC significantly reduced the

Table 4. Effect of succinic acid on germination of seeds under different levels of salt.

Concentration of		Duration of germination in hours				
Succinic acid mg/l	NaCl %	24	48	72	96	120
Control		0.0	93.30	98.66	99.33	99.33
0.0	1.0	0.0	26.33	88.00	97.83	98.83
0.0	1.5	0.0	2.50	23.66	34.83	63.16
0.0	2.0	0.0	0.00	0.00	0.00	0.00
5	1.0	0.0	30.16	85.00	96.16	98.33
10	1.0	0.0	34.66	83.83	96.66	98.33
20	1.0	0.0	34.83	84.66	96.50	98.83
5	1.5	0.0	5.66	32.33**	47.16**	73.50**
10	1.5	0.0	3.00	22.66	41.50**	65.86
20	1.5	0.0	2.50	24.16	40.66**	66.00
5	2.0	0.0	0.00	2.33	8.66**	14.00**
10	2.0	0.0	0.00	1.33	5.00	8.16
20	2.0	0.0	0.00	0.83	7.50**	13.00**
5	0.0	0.0	92.66	98.16	99.50	99.50
10	0.0	0.0	91.50	99.50	99.60	99.60
20	0.0	0.0	92.00	99.16	99.33	99.33
LSD at 1% level		0.0	10.44	6.31	5.32	8.52
LSD at 5% level		0.0	7.74	4.68	3.95	6.32

** Significant at 1% level.

Table 5. Effect of succinic acid on growth of seedlings under different levels of salt.

Concentration of		Length of	
Succinic acid mg/l	NaCl %	Root in millimeter	Shoot in millimeter
C o n t r o l		77.15	52.11
0.0	1.0	35.13	13.41
0.0	1.5	5.92	3.50
0.0	2.0	0.00	0.00
5	1.0	34.58	17.08
10	1.0	34.21	15.46
20	1.0	32.70	14.86
5	1.5	5.00	6.28
10	1.5	4.68	4.53
20	1.5	4.28	4.41
5	2.0	0.26	0.65
10	2.0	0.16	0.43
20	2.0	0.15	0.51
5	0.0	79.80	58.23**
10	0.0	71.80	54.40
20	0.0	80.13	57.32*
L S D at 1% level		6.01	5.30
L S D at 5% level		4.46	3.93

* Significant at 5% level.

** " " 1% "

percentage of germination of seeds at 1.0% level of salt (Table 6). Germination of seeds was totally inhibited by CCC at 1.5 and 2.0% level of salt.

Growth of seedlings was also inhibited by all levels of CCC tried (Table 7). At 1.0% level of salt, all concentrations of CCC brought about a significant reduction in the growth of seedlings.

Effect of thiourea on germination of seeds and growth of seedlings under different levels of salt

Pre-sowing soaking treatment of seeds with thiourea improved the germination of seeds at all levels of salt (Table 8). Thiourea at a concentration of 0.5% significantly increased the germination of seeds. Under the influence of thiourea 18% germination of seeds was observed even at 2.0% level of salt. Thiourea at concentrations of 0.5 and 1.0% significantly enhanced the growth of seedlings (Table 9). However, it failed to bring about any significant increase in the growth of seedlings under the influence of salt.

Effect of proline on germination of seeds and growth of seedlings under different levels of salt

Treatment of seeds with proline did not bring about

Table 6. Effect of CCC on germination of seeds under different levels of salt.

Concentration of		Duration of germination in hours				
CCC mg/l	NaCl %	24	48	72	96	120
Control		0.0	98.00	99.83	99.83	99.83
0.0	1.0	0.0	28.83	88.50	97.00	97.66
0.0	1.5	0.0	14.50	30.33	46.00	57.66
0.0	2.0	0.0	0.00	0.00	0.00	0.00
500	1.0	0.0	3.33**	22.16**	29.43**	40.66**
500	1.5	0.0	0.00	0.00	0.00	0.00
500	2.0	0.0	0.00	0.00	0.00	0.00
1000	1.0	0.0	2.33**	18.83**	26.16**	45.66**
1000	1.5	0.0	0.00	0.00	0.00	0.00
1000	2.0	0.0	0.00	0.00	0.00	0.00
1500	1.0	0.0	6.50**	21.66**	31.50**	49.50**
1500	1.5	0.0	0.00	0.00	0.00	0.00
1500	2.0	0.0	0.00	0.00	0.00	0.00
500	0.0	0.0	97.33	99.00	99.00	99.00
1000	0.0	0.0	98.50	99.33	99.50	99.50
1500	0.0	0.0	98.33	99.16	99.66	99.66
LSD at 1% level		0.0	8.09	10.81	11.58	12.87
LSD at 5% level		0.0	5.99	8.02	8.59	9.55

** Significant at 1% level.

Table 7. Effect of CCC on growth of seedlings under different levels of salt.

Concentration of		Length of	
CCC mg/l	NaCl %	Root in millimeter	Shoot in millimeter
C o n t r o l		71.70	47.86
0.0	1.0	15.70	11.41
0.0	1.5	1.84	3.73
0.0	2.0	0.00	0.00
500	1.0	1.66**	3.26**
500	1.5	0.00	0.00
500	2.0	0.00	0.00
1000	1.0	0.90**	2.10**
1000	1.5	0.00	0.00
1000	2.0	0.00	0.00
1500	1.0	1.21**	3.33**
1500	1.5	0.00	0.00
1500	2.0	0.00	0.00
500	0.0	26.06**	45.28
1000	0.0	5.58**	41.41**
1500	0.0	4.15**	42.20**
L S D at 1% level		6.90	4.35
L S D at 5% level		5.12	3.22

** Significant at 1% level.

Table 8. Effect of thiourea on germination of seeds under different levels of salt.

Concentration of		Duration of germination in hours				
Thiourea %	NaCl %	24	48	72	96	120
Control		0.0	98.0	100.0	100.0	100.0
0.0	1.0	0.0	32.0	90.0	96.0	97.0
0.0	1.5	0.0	4.0	8.0	23.0	54.0
0.0	2.0	0.0	0.0	0.0	0.0	0.0
0.2	1.0	0.0	23.0	77.0	98.5	99.5
0.5	1.0	0.0	25.0	80.0	99.0	100.0
1.0	1.0	0.0	22.0	70.0	96.0	99.0
0.2	1.5	0.0	2.5	8.5	27.5*	57.0
0.5	1.5	0.0	5.5	11.0	31.0**	64.0*
1.0	1.5	0.0	3.5	6.0	24.0	58.0
0.2	2.0	0.0	0.0	2.0	8.0**	10.0*
0.5	2.0	0.0	0.0	4.0	13.0**	18.0**
1.0	2.0	0.0	0.0	3.0	11.0**	14.0**
0.2	0.0	0.0	97.0	98.0	98.5	99.0
0.5	0.0	0.0	99.5	100.0	100.0	100.0
1.0	0.0	0.0	96.0	98.0	98.5	99.0
LSD at 1% level		0.0	5.42	10.94	5.07	12.31
LSD at 5% level		0.0	4.02	8.12	3.76	9.13

* Significant at 5% level.

** Significant at 1% level.

Table 9. Effect of thiourea on growth of seedlings under different levels of salt.

Concentration of		Length of	
Thiourea %	NaCl %	Root in millimeters	Shoot in millimeters
C o n t r o l		58.40	43.25
0.0	1.0	30.30	16.75
0.0	1.5	4.60	9.55
0.0	2.0	0.00	0.00
0.2	1.0	33.10	15.65
0.5	1.0	35.40	18.70
1.0	1.0	27.25	14.30
0.2	1.5	1.60	4.25
0.5	1.5	2.50	9.55
1.0	1.5	1.30	4.80
0.2	2.0	1.00	1.80
0.5	2.0	1.20	2.20
1.0	2.0	1.00	1.90
0.2	0.0	62.60*	48.95*
0.5	0.0	70.10**	54.90**
1.0	0.0	68.00**	53.60**
L S D at 1% level		4.93	6.61
L S D at 5% level		3.65	4.91

* Significant at 5% level.

** Significant at 1% level.

any increase in germination as compared to control (Table 10). Proline tried at all concentrations enhanced the rate as well as the final percentage of germination of seeds under the influence of salt at a concentration of 1.5%. Germination of seeds at 1.5% level of salt was significantly increased by proline at a concentration of 10 mg/l. There was no marked effect of proline on germination of seeds at 2.0% level of salt.

Treatment of seeds with proline adversely affected the growth of seedlings (Table 11). The inhibitory effect of proline was more pronounced on the growth of root system as compared to that of shoot system.

Effect of 2-chloroethanol on germination of seeds and growth of seedlings under different levels of salt

2-chloroethanol tried at all concentrations failed to improve the germination of seeds (Table 12). However, germination of seeds under the influence of 1.5% salt was significantly increased by 2-chloroethanol at 0.02% and 0.04%. A maximum of 13% germination of seeds was observed at 2.0% level of salt under the influence of 0.02% 2-chloroethanol. Higher concentrations of 2-chloroethanol tried were found to reduce the germination of seeds at 1.5% of salt.

Table 10. Effect of proline on germination of seeds under different levels of salt.

Concentration of		Duration of germination in hours				
Proline mg/l	NaCl %	24	48	72	96	120
Control		0.0	99.0	99.0	99.0	99.0
0.0	1.0	0.0	25.0	88.0	99.0	99.0
0.0	1.5	0.0	2.5	9.0	25.0	55.0
0.0	2.0	0.0	0.0	0.0	0.0	0.0
5	1.0	0.0	26.0	85.0	98.0	98.5
10	1.0	0.0	26.0	92.0	99.0	99.5
25	1.0	0.0	27.0	94.0	97.0	98.0
5	1.5	0.0	4.0	13.0	34.0**	66.0**
10	1.5	0.0	7.0**	16.0**	43.0**	76.0**
25	1.5	0.0	4.0	8.0	36.0**	54.0
5	2.0	0.0	0.0	1.5	3.0	3.5
10	2.0	0.0	0.0	3.5	8.6**	9.0**
25	2.0	0.0	0.0	2.0	2.5	3.5
5	0.0	0.0	97.0	98.5	99.0	99.0
10	0.0	0.0	99.5	99.5	99.5	99.5
25	0.0	0.0	96.5	97.5	97.5	97.5
LSD at 1% level		0.0	3.87	5.42	5.59	7.11
LSD at 5% level		0.0	2.87	4.02	4.15	5.28

** Significant at 1% level.

Table 11. Effect of proline on growth of seedlings under different levels of salt.

Concentration of		Length of	
Proline mg/l	NaCl %	Root in millimeters	Shoot in millimeters
C o n t r o l		68.55	42.75
0.0	1.0	18.90	13.00
0.0	1.5	1.80	8.70
0.0	2.0	0.00	0.00
5	1.0	16.10	11.50
10	1.0	16.95	15.15
25	1.0	14.80	12.50
5	1.5	1.00	8.70
10	1.5	1.98	9.25
25	1.5	1.25	7.65
5	2.0	0.00	0.30
10	2.0	0.00	0.90
25	2.0	0.00	0.55
5	0.0	45.20**	34.45**
10	0.0	55.50**	44.20
25	0.0	52.50**	38.35*
L S D at 1% level		7.98	6.99
L S D at 5% level		5.92	5.19

* Significant at 5% level.

** Significant at 1% level.

Table 12. Effect of 2-chloroethanol on germination of seeds under different levels of salt.

Concentration of 2-chloroethanol %	Concentration of NaCl %	Duration of germination in hours 24	48	72	96	120
Control		0.0	98.0	100.0	100.0	100.0
0.0	1.0	0.0	54.0	90.0	100.0	100.0
0.0	1.5	0.0	24.0	48.0	56.0	70.0
0.0	2.0	0.0	0.0	0.0	0.0	0.0
0.02	1.0	0.0	42.0	90.0	100.0	100.0
0.04	1.0	0.0	46.0	84.0	100.0	100.0
0.06	1.0	0.0	32.0	76.0	98.0	99.0
0.08	1.0	0.0	30.0	76.0	98.0	98.0
0.1	1.0	0.0	22.0	70.0	95.0	96.0
0.5	1.0	0.0	20.0	26.0	94.0	96.0
0.02	1.5	0.0	10.0	42.0	64.0**	82.0**
0;04	1.5	0.0	12.0	44.0	64.0**	78.0**
0.06	1.5	0.0	4.0	58.0**	68.0**	76.0*
0.08	1.5	0.0	4.0	50.0	64.0**	76.0*
0.1	1.5	0.0	0.0	34.0	38.0	48.0
0.5	1.5	0.0	0.0	10.0	14.0	26.0
0.02	2.0	0.0	0.0	8.0	9.0**	13.0**
0.04	2.0	0.0	0.0	7.0	9.0**	10.0**
0.06	2.0	0.0	0.0	8.0	9.0**	11.0**
0.08	2.0	0.0	0.0	7.0	8.0**	10.0**
0.1	2.0	0.0	0.0	3.0	4.0	5.0*
0.5	2.0	0.0	0.0	0.0	0.0	0.0
0.02	0.0	0.0	99.0	100.0	100.0	100.0
0.04	0.0	0.0	99.0	100.0	100.0	100.0
0.06	0.0	0.0	98.0	99.0	99.0	100.0
0.08	0.0	0.0	98.0	99.0	99.0	99.0
0.1	0.0	0.0	97.0	98.0	98.0	99.0
0.5	0.0	0.0	96.0	97.0	97.0	98.0
LSD at 1% level		0.0	5.87	8.23	5.82	6.49
LSD at 5% level		0.0	4.40	6.17	4.36	4.87

* Significant at 5% level. ** Significant at 1% level.

Treatment of seeds with 0.02% 2-chloroethanol slightly improved the growth of root and shoot system under the influence of salt at 1.0 and 1.5% concentrations (Table 13).

Effect of IAA on germination of seeds and growth of seedlings under different levels of salt

Treatment of seeds with IAA (all concentrations tried) significantly increased the germination of seeds under the influence of salt at 1.5 and 2.0% (Table 14). IAA at a concentration of 4 mg/l showed the maximum stimulation of germination.

The growth of root system of seedlings was slightly enhanced by IAA (Table 15). The growth of shoot system was reduced by IAA as compared to the control. The growth of root system of seedlings at all levels of salt was slightly stimulated by IAA tried at all concentrations.

Effect of GA_3 on germination of seeds and growth of seedlings under different levels of salt.

Treatment of seeds with GA_3 did not bring about any increase in germination as compared to the control (Table 16).

Table 13. Effect of 2-chloroethanol on growth of seedlings under different levels of salt.

Concentration of		Length of	
2-chloroethanol %	NaCl %	Root in millimeters	Shoot in millimeters
C o n t r o l		52.0	46.6
0.0	1.0	28.4	16.2
0.0	1.5	5.0	8.0
0.0	2.0	0.0	0.0
0.02	1.0	32.0	19.4
0.04	1.0	28.6	15.0
0.06	1.0	26.4	15.6
0.08	1.0	25.8	15.4
0.1	1.0	25.6	13.6
0.5	1.0	15.2	7.8
0.02	1.5	8.0	8.6
0.04	1.5	5.6	7.0
0.06	1.5	7.2	8.4
0.08	1.5	6.6	6.4
0.1	1.5	6.6	6.4
0.5	1.5	0.0	1.4
0.02	2.0	0.0	1.5
0.04	2.0	0.0	1.2
0.06	2.0	0.0	1.2
0.08	2.0	0.0	1.2
0.1	2.0	0.0	1.1
0.5	2.0	0.0	0.0
0.02	0.0	55.0	48.0
0.04	0.0	52.0	46.0
0.06	0.0	49.0	47.0
0.08	0.0	50.0	46.5
0.1	0.0	50.0	47.0
0.5	0.0	47.0	40.0
L S D at 1% level		6.51	5.50
L S D at 5% level		4.88	4.13

Table 14. Effect of IAA on germination of seeds under different levels of salt.

Concentration of		Duration of germination in hours				
IAA mg/l	NaCl %	24	48	72	96	120
Control		0.0	94.90	95.90	96.50	99.90
0.0	1.0	0.0	33.90	65.90	89.50	94.00
0.0	1.5	0.0	2.20	26.10	41.90	74.50
0.0	2.0	0.0	0.00	0.00	0.00	0.00
1.0	1.0	0.0	36.50**	80.25**	91.50	95.90
2.0	1.0	0.0	37.00	82.50**	91.90	96.00
4.0	1.0	0.0	39.90	86.50**	93.50	97.50
1.0	1.5	0.0	9.50	30.50	58.80**	79.85
2.0	1.5	0.0	12.30	28.90	60.50**	80.50
4.0	1.5	0.0	18.95	33.81	66.35**	82.35*
1.0	2.0	0.0	0.0	5.90	10.00**	12.50**
2.0	2.0	0.0	0.0	5.90	11.50**	16.50**
4.0	2.0	0.0	0.0	6.20	12.85**	18.90**
1.0	0.0	0.0	95.80	98.00	99.50	99.50
2.0	0.0	0.0	95.00	99.00	99.90	99.90
4.0	0.0	0.0	97.00	99.90	100.00	100.00
LSD at 1% level		-	6.36	9.67	7.29	9.01
LSD at 5% level		-	4.71	7.16	5.41	6.69

* Significant at 5% level

** Significant at 1% level.

Table 15. Effect of IAA on growth of seedlings under different levels of salt.

Concentration of		Length of	
IAA mg/l	NaCl %	Root in millimeters	Shoot in millimeters
C o n t r o l		72.90	50.39
0.0	1.0	24.50	14.80
0.0	1.5	5.20	4.95
0.0	2.0	0.00	0.00
1.0	1.0	25.80	13.90
2	1.0	27.90	12.85
4	1.0	28.65	11.50
1	1.5	6.40	3.50
2	1.5	6.60	2.90
4	1.5	7.00	2.50
1	2.0	1.00	0.95
2	2.0	1.20	0.80
4	2.0	1.30	0.80
1	0.00	78.50*	43.00
2	0.0	78.90*	40.50
4	0.0	80.50*	40.00
LSD at 1% level		7.29	7.64
LSD at 5% level		5.41	5.67

* Significant at 5% level.

Table 16. Effect of gibberellic acid on germination of seeds under different levels of salt.

Concentration of		Duration of germination in hours				
GA_3 mg/l	NaCl %	24	48	72	96	120
Control		0.0	99.8	99.8	99.8	99.9
0	1.0	0.0	32.1	67.8	88.1	96.5
0	1.5	0.0	1.6	24.1	42.8	73.5
0	2.0	0.0	0.0	0.0	0.0	0.0
5	1.0	0.0	42.0**	90.8**	98.1**	98.8
5	1.5	0.0	13.0**	38.5**	65.0**	89.0**
5	2.0	0.0	0.0	8.5**	19.5**	30.5**
10	1.0	0.0	49.0**	94.0	95.6**	98.9
10	1.5	0.0	26.0**	48.5**	74.0**	91.0**
10	2.0	0.0	0.0	19.5**	27.0**	52.5**
25	1.0	0.0	48.0**	91.0**	93.5**	97.5
25	1.5	0.0	25.0**	45.5**	72.0**	89.5**
25	2.0	0.0	0.0	18.0**	25.0**	42.5**
5	0.0	0.0	98.0	98.5	99.0	99.5
10	0.0	0.0	99.6	99.8	99.8	100.0
25	0.0	0.0	99.0	99.5	99.5	99.6
LSD at 1% level		0.0	5.46	2.22	4.59	3.96
LSD at 5% level		0.0	4.05	1.64	3.41	2.94

** Significant at 1% level.

GA_3 tried at all concentrations enhanced the rate of emergance of seeds at 1.0% level of salt especially during the early stages of germination. The rate of emergance and final percentage of germination of seeds under the influence of 1.5% salt were significantly enhanced by all concentrations of GA_3 tried. GA_3 tried at all concentrations induced the germination in seeds even at 2.0% level of salt at which seeds failed to germinate. A maximum of 52% germination was observed at a level of 2.0% salt under the influence of 10 mg/l GA_3.

Treatment of seeds with GA_3 resulted in a stimulation of growth of seedlings (Table 17). Maximum stimulation of growth was observed under 10 mg/l GA_3. Treatment of seeds with GA_3 stimulated the growth of root and shoot of seedlings at 1.0% level of salt. At higher concentrations of salt (1.5 and 2.0%) the stimulation of growth by GA_3 was seen more in shoot than in root.

To understand the various mechanisms by which GA_3 brings about the germination of seeds under the toxic level of salt, the following studies were carried out :

1. Changes in the dry weight of endosperm
2. Changes in the major cellular constituents of endosperm

Table 17. Effect of gibberellic acid on germination of seeds under different levels of salt.

Concentration of		Length of	
GA_3 mg/l	NaCl %	Root in millimeters	Shoot in millimeters
C o n t r o l		74.02	49.38
0	1.0	22.87	15.00
0	1.5	4.13	4.80
0	2.0	0.00	0.00
5	1.0	25.15	17.88*
10	1.0	26.05	18.25*
25	1.0	23.15	16.35
5	1.5	4.50	7.25*
10	1.5	4.90	8.20*
25	1.5	4.15	5.62
5	2.0	1.00	2.27
10	2.0	1.00	2.81*
25	2.0	1.00	2.07
5	0.0	82.45**	52.47*
10	0.0	83.50**	58.80**
25	0.0	80.33**	50.13
L S D at 1% level		5.58	3.58
L S D at 5% level		4.14	2.65

* Significant at 5% level.

** Significant at 1% level.

3. Activity of amylases, invertase, maltase, protease and phytase in the endosperm of seeds during germination under the influence of salt and GA_3, salt alone and GA_3 alone.

Changes in the dry weight of endosperm of paddy during germination

Endosperm of resting seed showed a dry weight of 18.3 mg and it decreased steadily as germination progressed. At the end of 120 hours of germination more than 31% of the initial dry weight got lost. When seeds were set for germination in presence of salt, no appreciable change in the weight of endosperm was observed. When seeds were treated with 10 mg/l GA_3 and then set for germination in presence of salt, a slight reduction in the dry weight of endosperm was observed. Treatment of seeds with GA_3 alone resulted in a rapid loss in dry weight of endosperm during germination. By the end of 120 hours of germination more than 38% of the initial dry weight of endosperm was found lost. (Table 18).

Changes in the major cellular contents of endosperms of paddy during germination

Starch

It has been observed that the endosperm of ungerminated

Table 18. Effect of GA_3 on changes in dry weight of endosperm under different levels of salt.

Concentration of		Duration of germination in hours					
GA_3 mg/l	NaCl %	0	24	48	72	96	120
Control		18.3	17.4	16.5	15.2	13.1	12.5
0	2.0	18.3	18.0	17.8	17.7	17.7	17.6
10	2.0	18.3	18.1	17.4	17.3**	17.0**	16.7**
10	0.0	18.3	17.3	15.5	14.8	12.6	11.2
LSD at 1% level		0.237	0.237	0.441	0.343	0.089	0.586
LSD at 5% level		0.157	0.157	0.292	0.227	0.059	0.387

** Significant at 1% level.

seed contain 16.3 mg of starch and it accounted for 89.1% of its dry weight (Fig. 1). During germination of seed the starch content of the endosperm decreased to 50% of its initial level at 120 hrs. The maximum rate of depletion of starch was observed during 96 to 120 hrs of germination. However, in presence of salt, the depletion of starch declined sharply and only a reduction of 15% of its initial level was observable at the end of 120 hrs of germination. Treatment of seeds with 10 mg/l GA_3 enhanced the depletion of starch by 12% by the end of 120 hrs of germination as compared to that of its control (salt alone). A rapid rate of depletion of starch was observed during germination of seeds under the influence of GA_3 alone.

Total soluble sugars

The endosperm of dry seed contained 162.2 µgms of soluble sugars (Fig. 2). It increased steadily during germination and showed a 24 fold increase as compared to its initial level by the end of 5th day. In presence of salt the content of soluble sugars of endosperm remained almost steady till the end of 72 hours of germination and showed a slight decrease thereafter. Treatment of seeds with GA_3 enhanced the release of soluble sugars in the endosperm during germination of seeds at 2.0% salt. The amount of

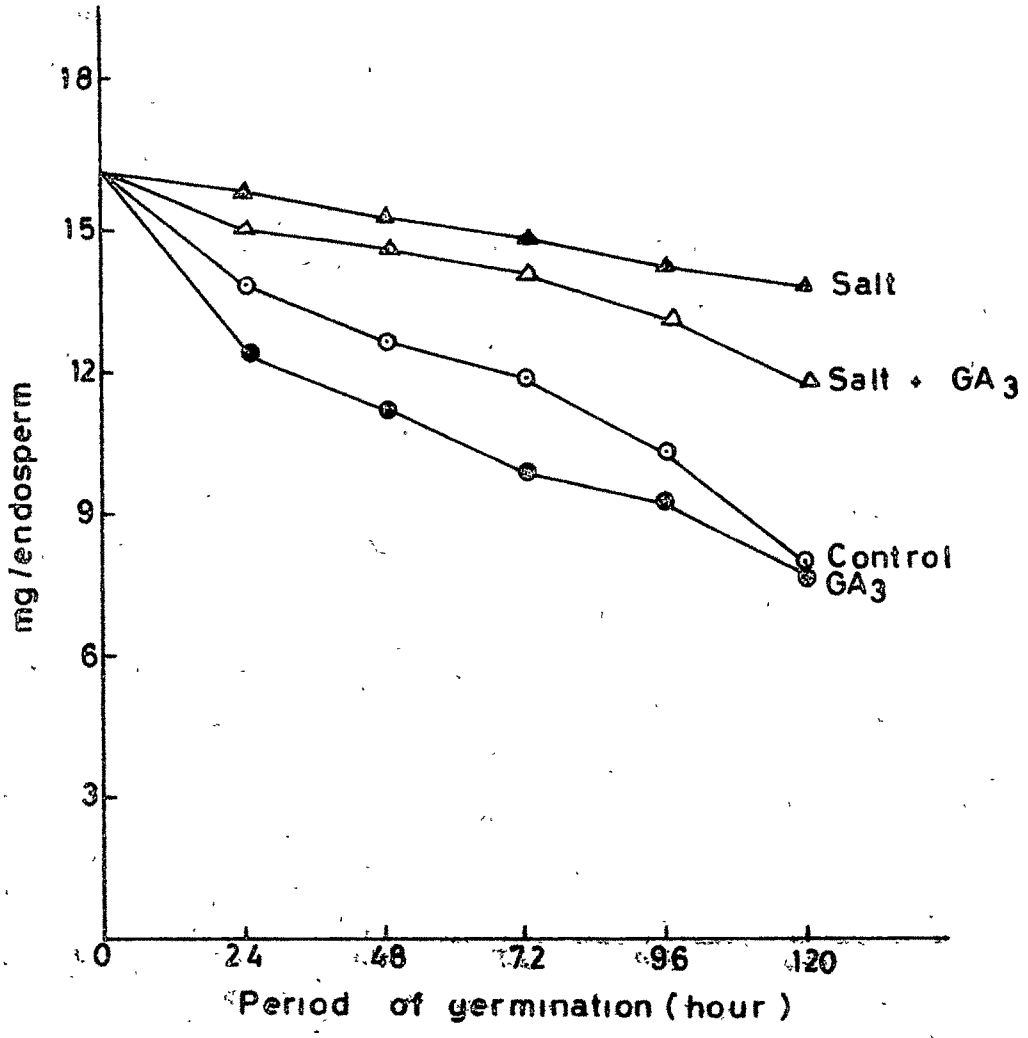

FIG. 1: CHANGES IN THE STARCH CONTENT OF ENDOSPERM OF PADDY DURING GERMINATION.

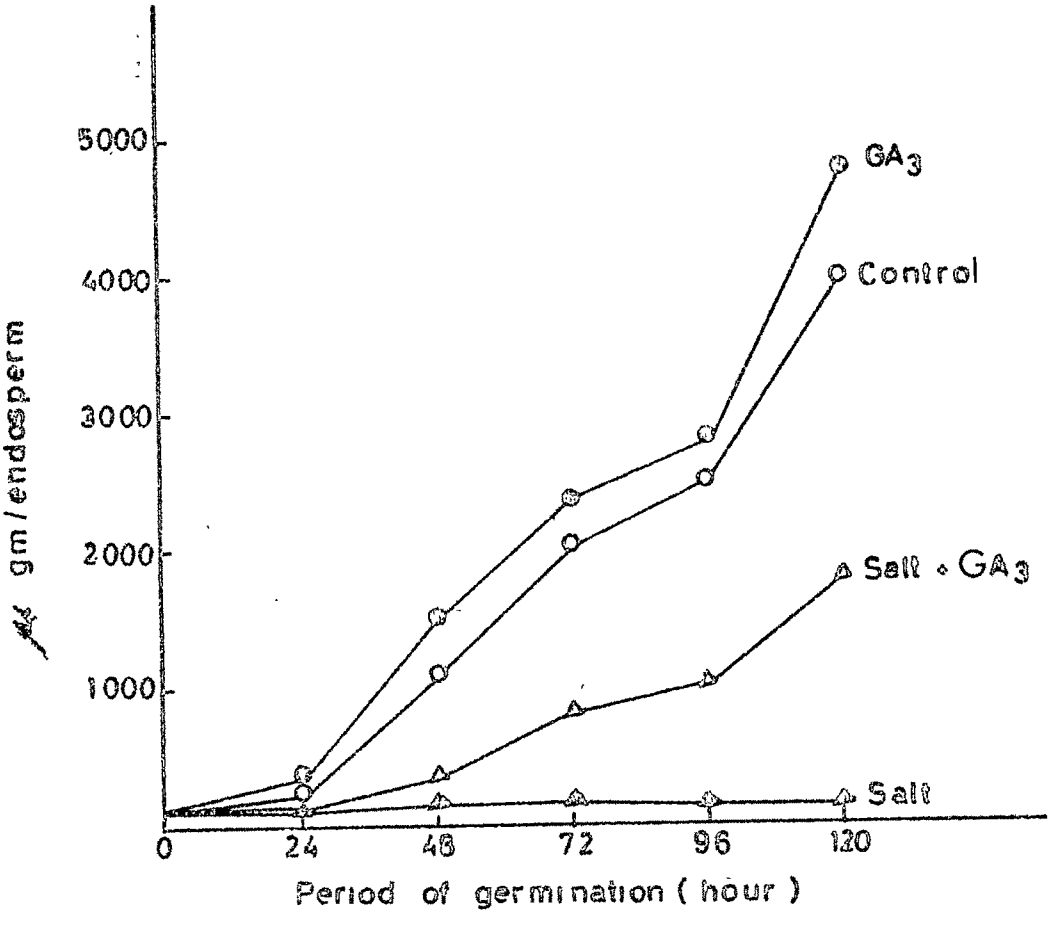

FIG. 2: CHANGES IN THE TOTAL SOLUBLE SUGAR CONTENT OF ENDOSPERM OF PADDY DURING GERMINATION.

soluble sugars observed at the end of 120 hours of germination of seeds at 2.0% level of salt under the influence of GA_3 was less than 50% of its level in the control. Treatment of seeds with GA_3 enhanced the production of soluble sugars during germination of seeds.

Reducing sugars

Endosperm of dry seed showed a very low level of reducing sugars (Fig. 3). As germination progressed the level of reducing sugars increased steadily and showed a 40 fold increase as compared to its initial level. During germination of seeds under the influence of salt there was no appreciable change in the content of reducing sugars of endosperm. However, treatment of seeds with GA_3 greatly enhanced the release of reducing sugars during germination. The level of reducing sugars observed in the endosperm of seed under the influence of salt and GA_3 at the end of 120 hours of germination was less than half of its level in control (pure control). During germination of seeds a rapid increase in the content of reducing sugars was observed in the endosperms under the influence of GA_3.

Total protein

Endosperm of dry seed contained 1.52 mg of protein and

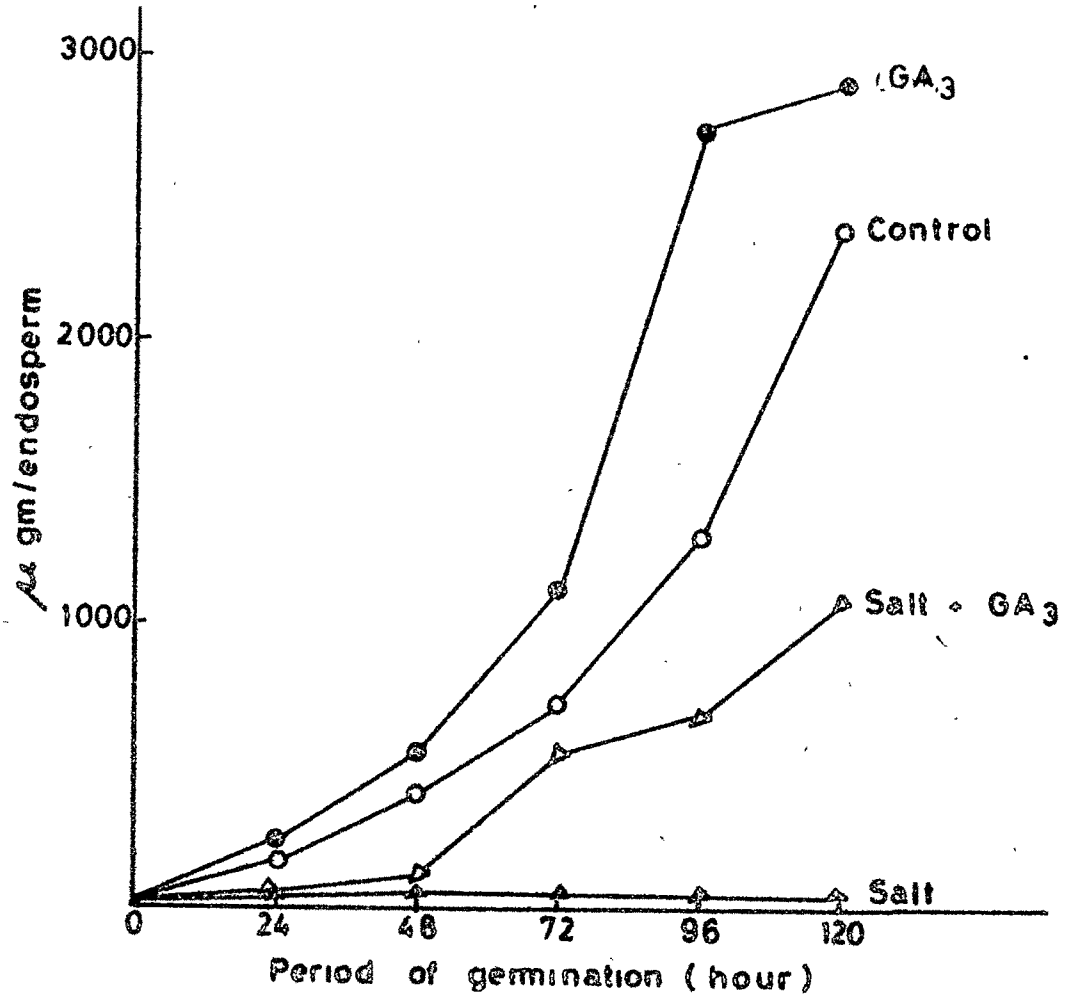

FIG 3 CHANGES IN THE CONTENT OF REDUCING SUGARS OF ENDOSPERM OF PADDY DURING GERMINATION.

it accounted for 8.3% of the dry weight of endosperm (Fig. 4). During germination the protein content decreased sharply and by the end of 120 hours of germination 55% of the total protein content got depleted. Incorporation of salt in the germination medium adversely affected the depletion of protein from the endosperm. However, treatment of seeds with GA_3 slightly enhanced the depletion of proteins. During germination GA_3 treated seeds showed a greater loss of protein as compared to control.

Total nitrogen

Endosperm of dry seed contained 65 µg of total nitrogen and it decreased gradually during germination (Fig. 5). By the end of 120 hours of germination of seeds 40% of the initial level of total nitrogen got depleted. Incorporation of salt in the germination medium highly inhibited the depletion of total nitrogen from the endosperm during the period of germination tried. Treatment of seeds with GA_3 slightly enhanced the depletion of total nitrogen from the endosperm during germination of seeds under the influence of salt. Treatment of seeds with GA_3 alone highly stimulated the process of depletion of nitrogen from the endosperm during germination of seeds.

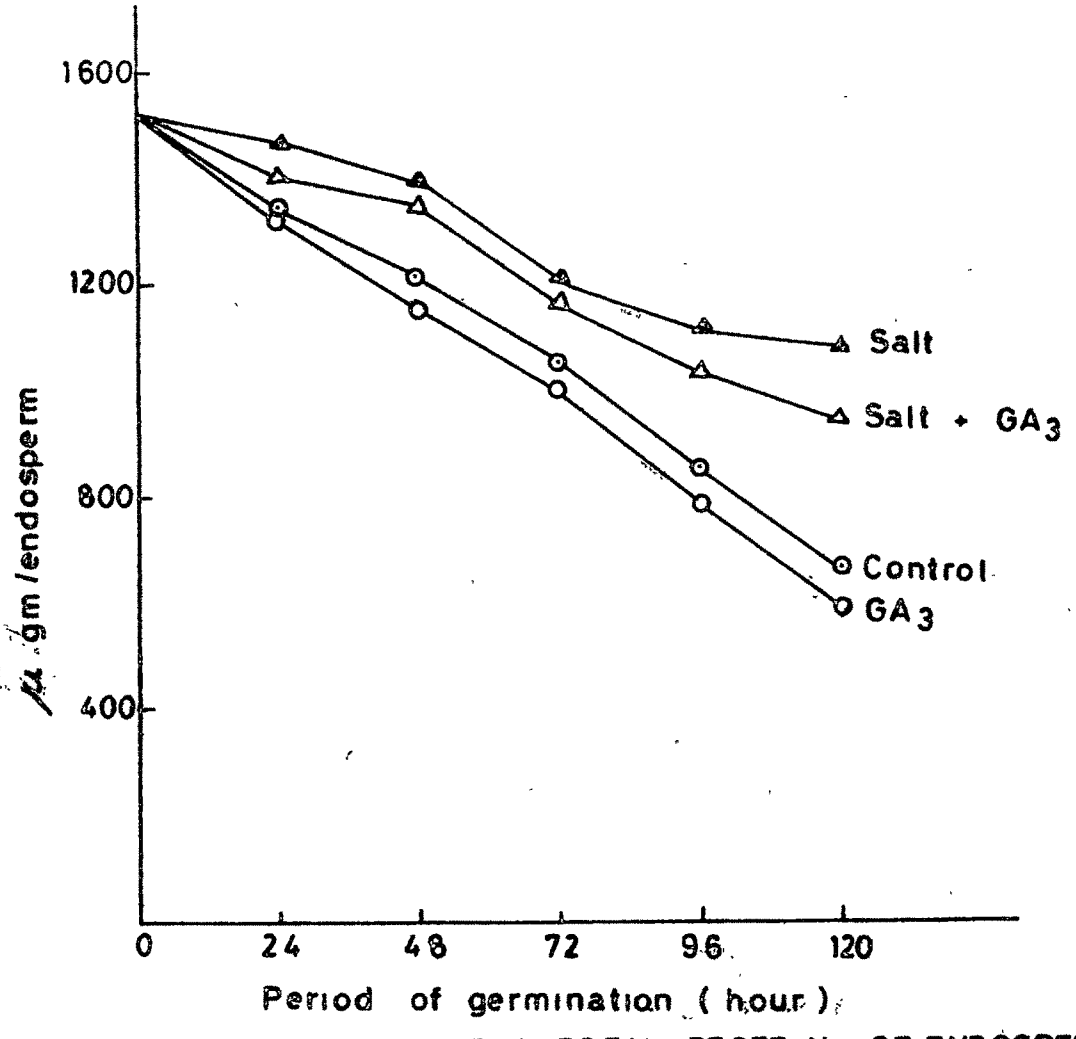

FIG. 4: CHANGES IN THE TOTAL PROTEIN OF ENDOSPERM OF PADDY DURING GERMINATION.

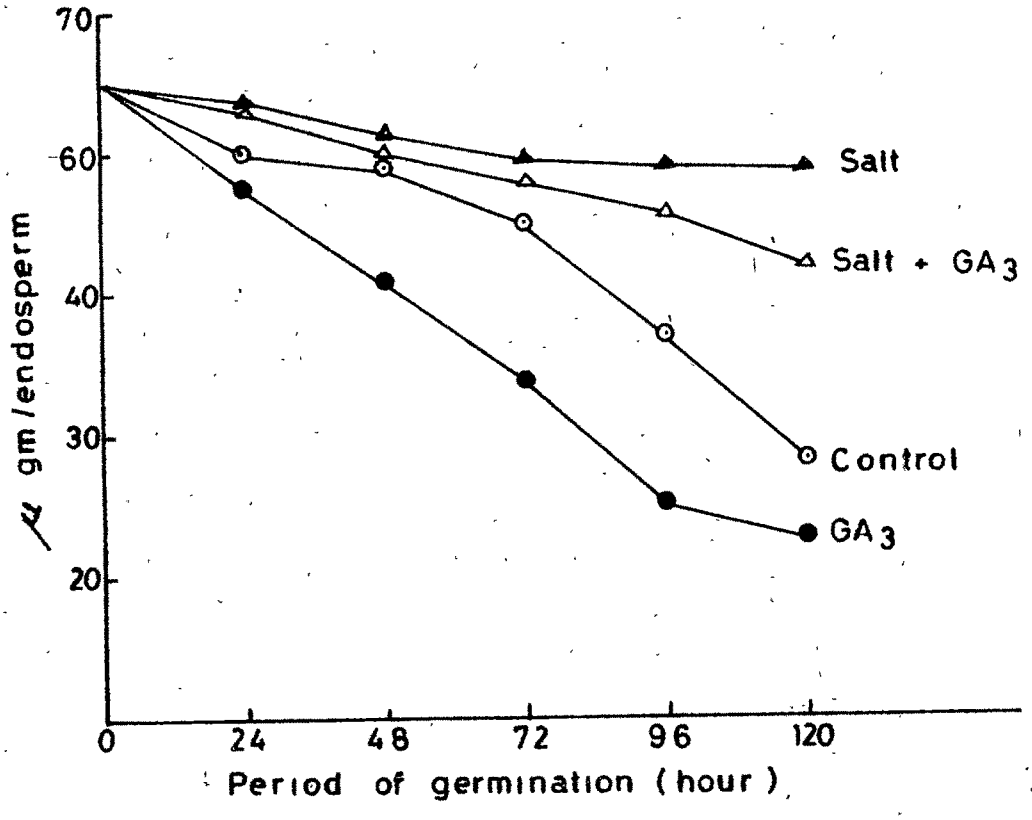

FIG. 5: CHANGES IN THE TOTAL NITROGEN CONTENT OF ENDOSPERM OF PADDY DURING GERMINATION.

Phytin

The phytin content of endosperm decreased rapidly and reached a very low level by the end of 120 hours of germination (Fig. 6). The highest reduction in the content of phytin was observed during 24 to 48 hours of germination. Under the influence of salt the phytin content reduced only slightly. Application of GA_3 to seeds highly enhanced the depletion of phytin under the influence of salt and by the end of 120 hours of germination of seeds more than 50% of the total phytin got depleted. Treatment of seeds with GA_3 alone slightly stimulated the depletion of phytin.

Action spectra of enzymes during germination of paddy

Amylases

A very low amylolytic activity was observed in endosperms of resting seeds (Fig. 7). The activity increased steadily during germination. A rapid increase in the activity was observed during 24 to 72 hours of germination. The amylolytic activity of seeds was highly inhibited by salt at a concentration of 2.0%. Treatment of seeds with GA_3 highly stimulated the amylolytic activity under the

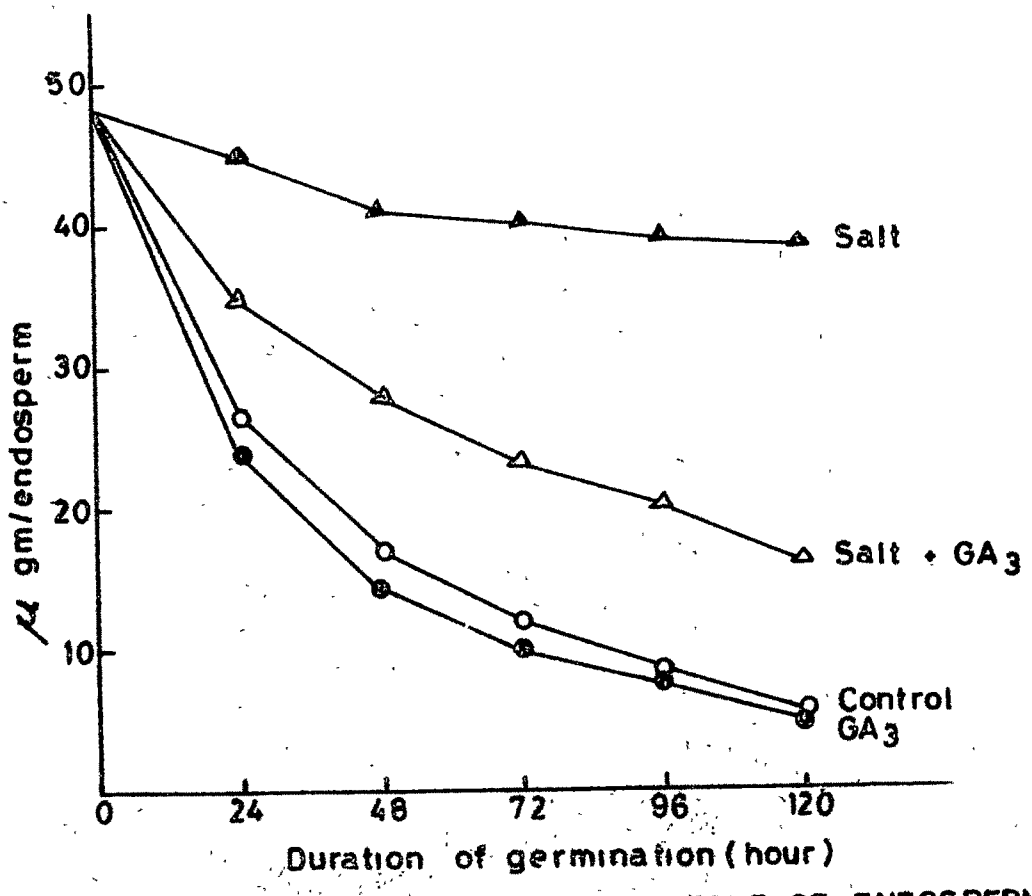

FIG 6 CHANGES IN THE PHYTIN CONTENT OF ENDOSPERM OF PADDY DURING GERMINATION.

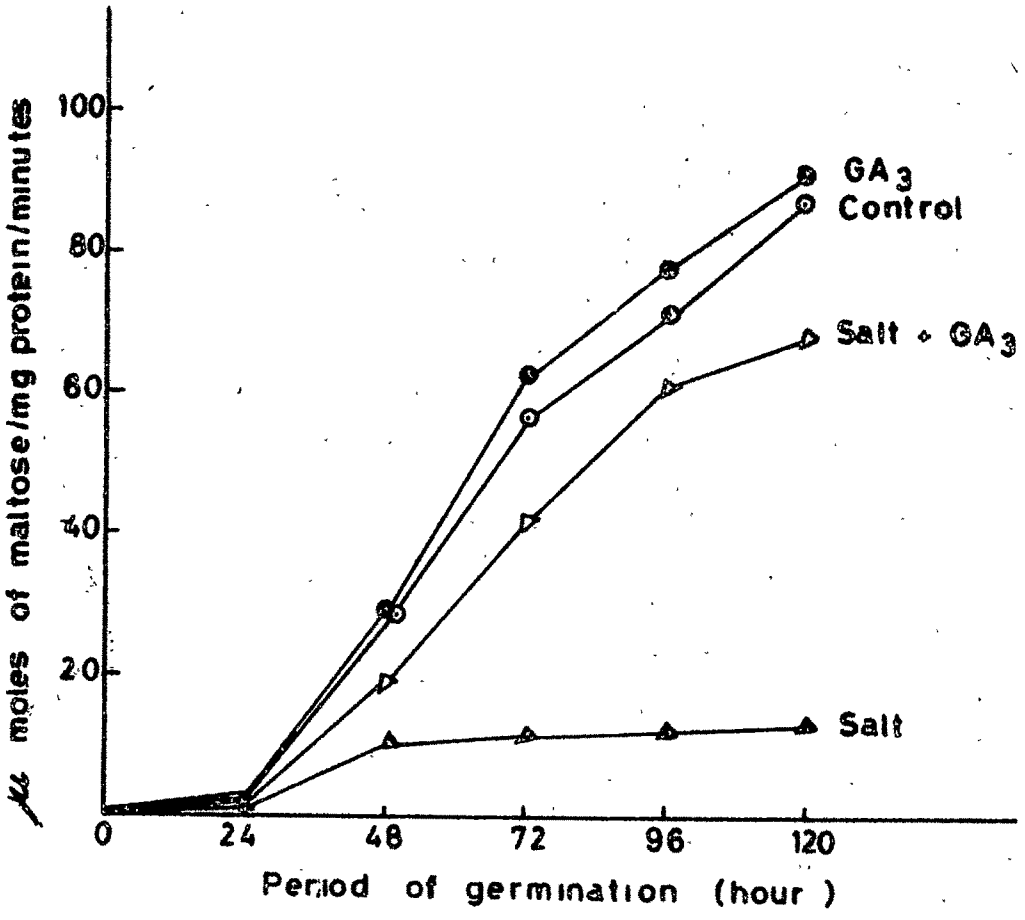

FIG 7 TOTAL AMYLOLYTIC ACTIVITY DURING GERMINATION OF PADDY.

influence of 2.0% salt. As compared to the activity in control seeds GA_3 treated ones showed a higher activity.

Activity of α-amylase was not detected in the resting seed (Fig. 8). The activity appeared after a lag phase of 48 hours and increased steadily thereafter. As in the case of total amylolytic activity, a very low activity of α-amylase was observed in seeds under the influence of 2 per cent salt. The enzyme activity under the influence of 2.0% salt showed a gradual decrease from 72 hours onwards and reached a very low level by the end of 120 hours. Treatment of seeds with GA_3 significantly increased the activity of amylase during germination of seeds even under 2.0% level of salt. However, this activity was lower than that of control. Seeds treated with GA_3 showed a higher activity of amylase as compared to that of control.

Endosperm of dry seeds exhibited activity of β-amylase (Fig. 9). The activity showed a slight increase during the first 24 hours of germination and thereafter it registered a steady increase upto 72 hours. Though the enzyme showed an increase in its activity even after 72 hours of germination the rate of increase of enzyme activity showed a decrease. In contrast to the

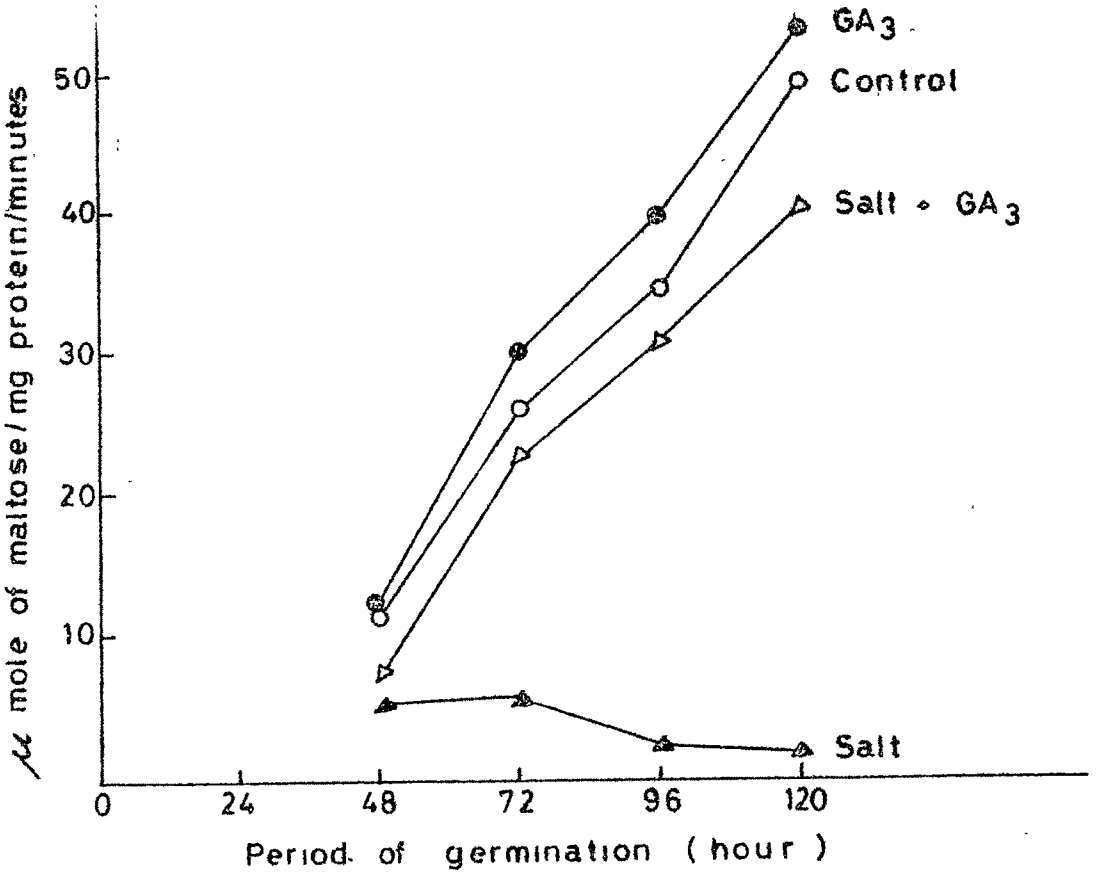

FIG 8: ACTIVITY OF ∝-AMYLASE DURING GERMINATION OF PADDY.

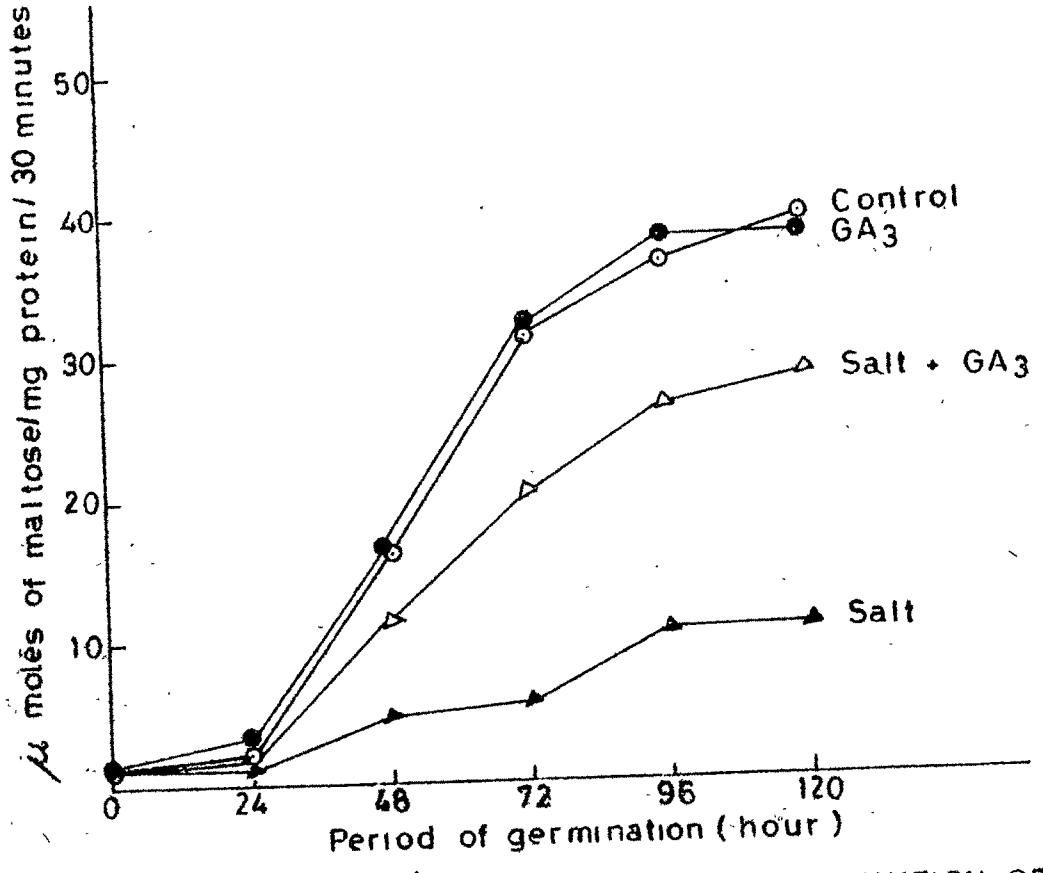

FIG 9 ACTIVITY OF β-AMYLASE DURING GERMINATION OF PADDY.

activity of β-amylase observed under the influence of 2.0% salt β-amylase showed a slight increase during the germination period. Treatment of seeds with GA_3 brought about a significant increase in the activity of amylase during germination under the influence of 2.0% salt. Activity of β-amylase during germination seeds was not stimulated by GA_3 treatment.

Invertase

The activity of invertase was not detected in the endosperms of dry seed (Fig. 10). The activity appeared only after a lag phase of 24 hours and registered a steady increase during germination of seeds. At the end of 120 hours of germination the enzyme showed a 8.5 fold increase in its activity as compared to its initial level. Under the influence of salt the activity showed a slight increase during 24 to 48 hours of germination and thereafter it remained almost steady. Treatment of seeds with GA_3 stimulated the activity of invertase during germination of seeds under the influence of salt. However, this activity was less than that of control. The activity of invertase was highly stimulated during germination of seeds under the influence of GA_3.

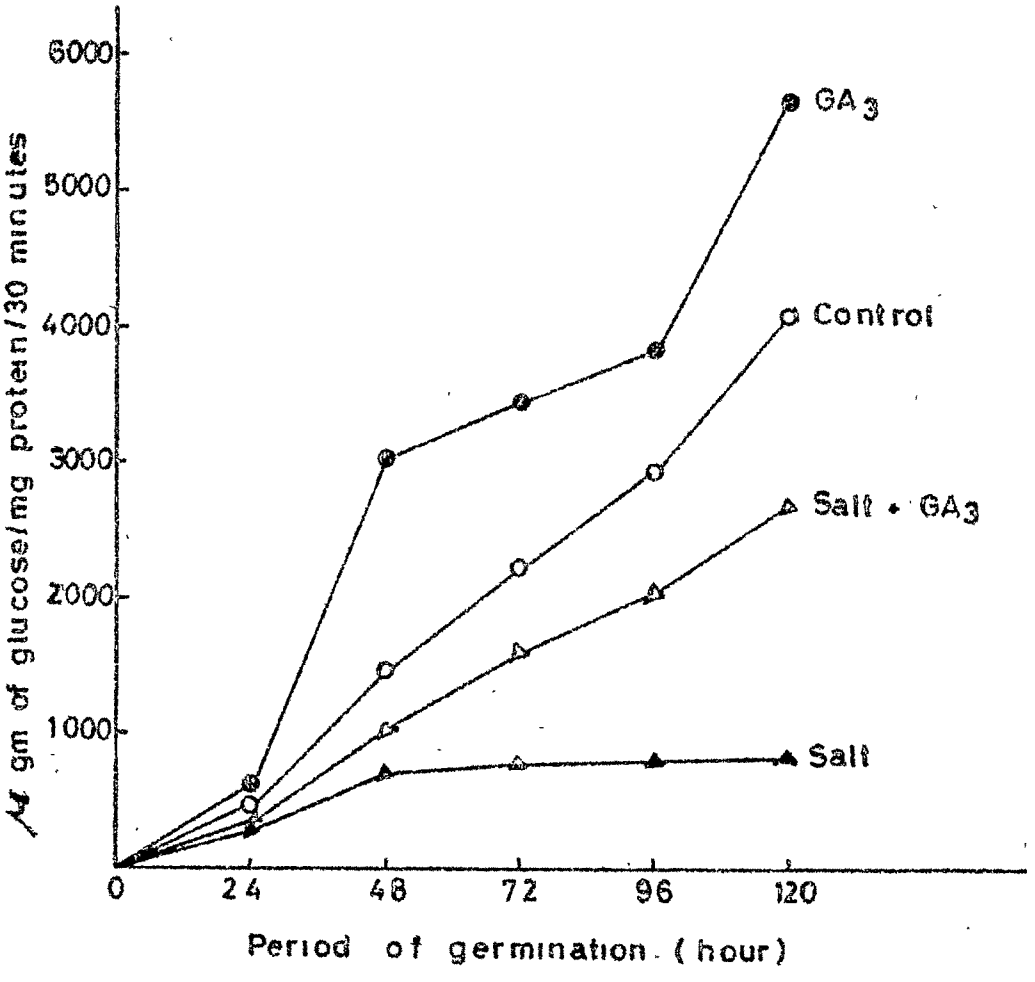

FIG. 10: ACTIVITY OF INVERTASE DURING GERMINATION OF PADDY.

Maltase

Endosperms of resting seeds showed a very low activity of maltase and it showed a rapid increase till the end of 48 hours of germination and remained almost constant till the end of 72 hours of germination (Fig. 11). The activity increased steadily from 72 hours onwards to reach the maximum by the end of 120 hours of germination. Under the influence of salt the activity of maltase have been found highly reduced. Treatment of seeds with GA_3 highly enhanced the activity of maltase of seeds under the influence of salt. The activity of maltase of GA_3 treated seeds showed a peak at the end of 48 hours of germination and declined to a slightly low level by the end of 72 hours of germination and increased steadily thereafter.

Protease

A very low activity of protease was observed in the endosperms of resting seeds (Fig. 12). The activity showed a rapid increase registering the peak at the end of 24 hours of germination and declined sharply thereafter to reach a low level by the end of 120 hours of germination. Under the influence of salt the protease activity of endosperms showed a slight increase and registered the

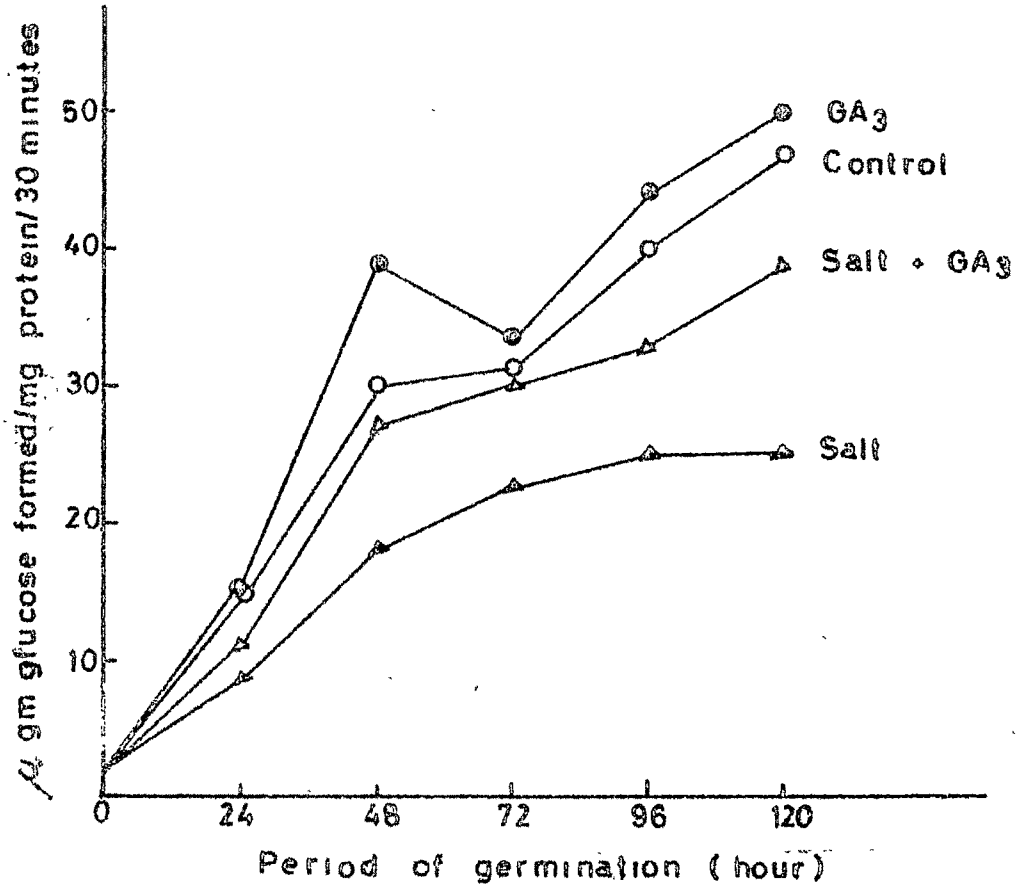

FIG. 11: ACTIVITY OF MALTASE DURING GERMINATION OF PADDY.

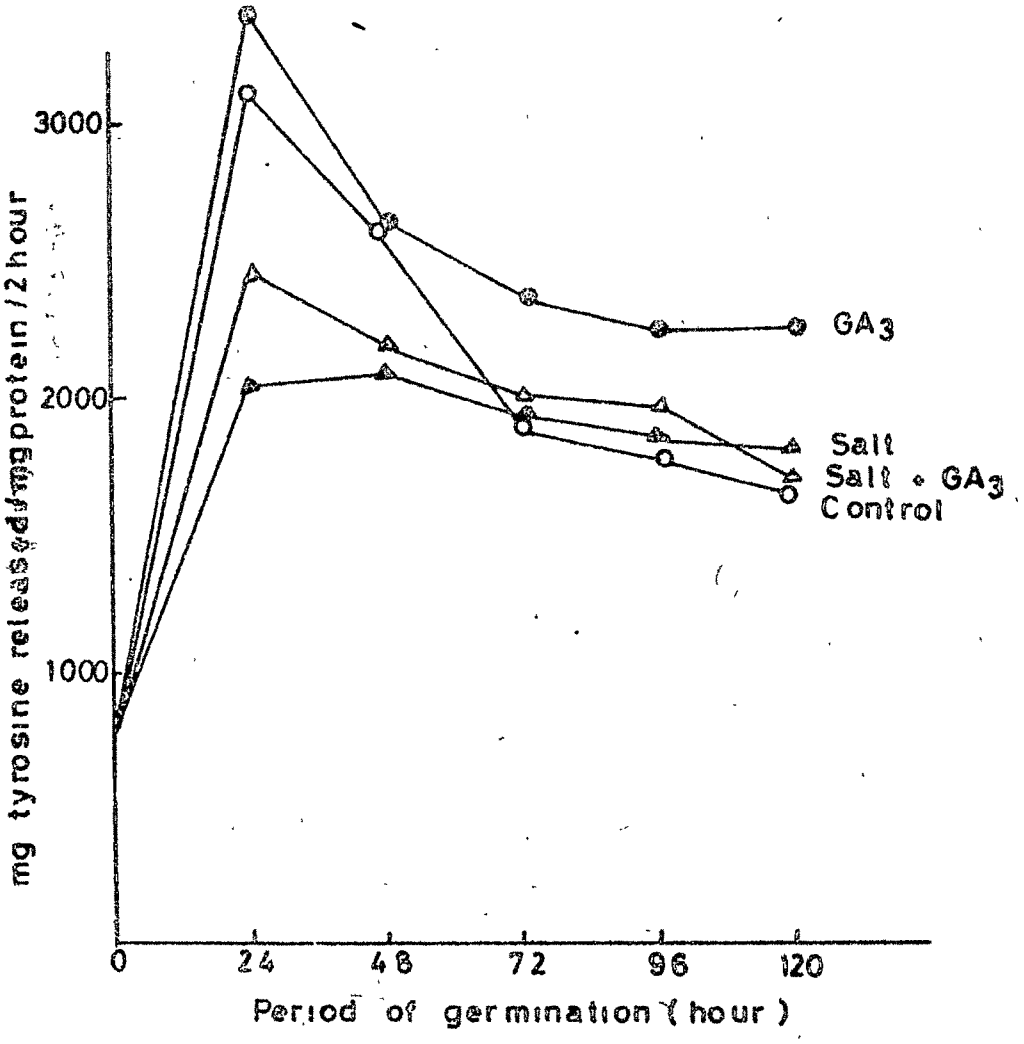

FIG. 12: ACTIVITY OF PROTEASE DURING GERMINATION OF PADDY.

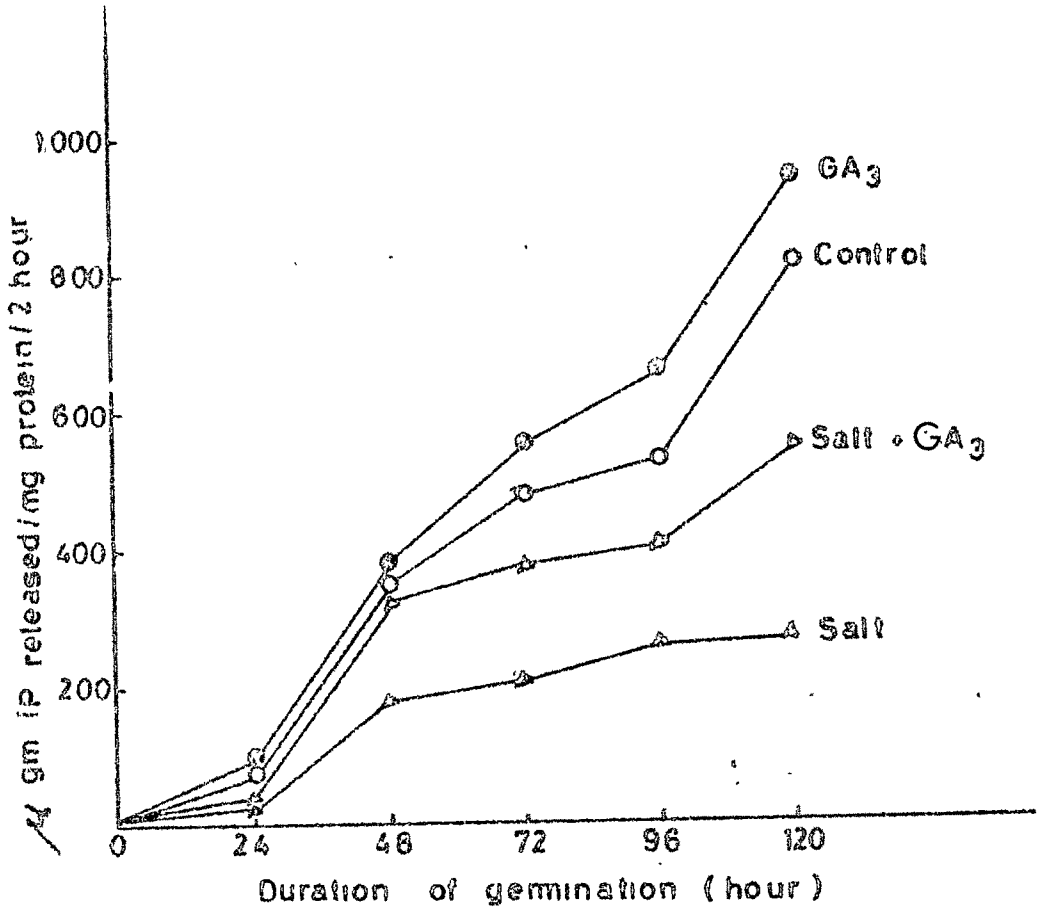

FIG 13 ACTIVITY OF PHYTASE GERMINATION OF PADDY.

peak at the end of 48 hours of germination and decreased thereafter. During germination of seeds under the influence of salt and GA_3 a slightly higher activity of protease was observed with the peak activity at the end of 24 hours of germination. Activity of protease in GA_3 treated seeds rose sharply registering the peak at the end of 24 hours of germination. and decreased sharply till the end of 48 hours. Only a slight decrease in the activity was observed from 48 hours onwards.

Phytase

A very low activity of phytase was detected in the endosperms of dry seeds (Fig. 13). The activity showed a steady increase during germination of seeds. By the end of 120 hours of germination a 10 fold increase in the activity of phytase as compared to its initial level was observed. The maximum rate of increase in the activity of the enzyme was observed during 24 to 48 hours of germination. Under the influence of salt a very low activity of phytase was observed during germination of seeds. Treatment of seeds with GA_3 highly increased the activity of phytase during germination under the influence of salt. However, this activity was less than that of control. Treatment of seeds with GA_3 alone resulted in a higher activity of phytase as compared to that of control.

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