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Effect of Growth Retardants on Sprouting and Development of Potato Tubers and their Biochemical contents

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ABSTRACT: Growth retardants are the chemicals that slows cell division and cell elongation of shoot tissue and regulate plant height physiologically without formative effects. Maleic Hydrazide (MH) is a plant growth retardant that reduces growth through preventing cell division but not cell enlargement. It is applied to foliage of potato to prevent sprouting during storage. In this study, Potato tubers were treated with MH at different concentration. The different developmental parameters such as sprouting, seedling length, no. of leaves, chlorophyll content and Sugar content were observed after some days. The result showed that number of sprouts were less in MH treated tubers than the controlled one. Seedling length reduced in MH treated tubers but the number of leaves were more in MH treated tubers. Again Chlorophyll content increased with the increasing concentration of MH. The sugar content was low in MH treated tubers. Thus the application of MH can induce the development by increasing leaves numbers and more chlorophyll content and yield of potato also increases.

Keywords: Growth retardants, Maleic Hydrazide, Cell division, Chlorophyll content, Sprouting.

INTRODUCTION

Potato (*Solanum tuberosum* L.) is the leading starchy tuber crop of the north temperate countries belonging to the Solanaceae family. The English word potato comes from the Spanish word "patata". Potato is one of the most important crops, ranking the annual production of which surpasses that of all other vegetables with considerable margin and ranks with wheat and rice. Its food productivity per hectare is about four times greater than that of cereals and it can be harvested before it reaches maturity, thus playing an important role in food security.

World potato production has increased at an annual average rate of 4.5 per cent over the last 10 years, exceeding the growth in production of many other major food commodities in developing countries, particularly in Asia. In India, potato is cultivated in over 14 lakh hectare across the country. More than 80 per cent of the potato crops are raised in gangetic plains in the winter season during October-March. Uttar Pradesh and west Bengal produce 32 per cent and 26 per cent respectively of potatoes produced in the country, followed by Bihar (11per cent), Assam (6 per cent) and Karnataka (4 per cent). The per capita consumption in India at 14.8kg is one of the lowest in the world.

The main reasons for the increasing popularity of the potato in 3rd world countries are the high nutritional value of the tubers combined with the simplicity of its propagation by vegetative amplification. In addition to its clear importance for food and feed, the tuber also represents the starting material for the next generation of plants; so called seed tuber. It is for this reason that process related to tuber formation, storage, and sprouting has been studied intensively over many years. The life cycle of a potato tuber is characterized by initiation and growth followed by a period of dormancy and finally sprouting resulting in the next vegetative generation. It is important to note that the period of dormancy cannot distinctly be separated from tuber initiation and enlargement. Thus dormancy is a process that largely parallels tuber enlargement.

The activity of maleic hydrazide (MH) as a plant growth regulator was first described in the journal *Science* by Schoene & Hoffman (1949).

Work on potato took place in the early 1950s with papers published for example by Smith (1951); Highlands *et al*. (1954), Paterson *et al*. (1952); Franklin & Thompson (1953).

Paterson *et al*. (1952) showed that MH inhibits apical dominance. They applied sprays of 500, 1000 and 2500ppm MH to cvs Irish Cobbler and Pontiac on 4 dates July 15 –Aug 19 and Jul 15 - Sep 2 respectively. Haulm kill was 2 days after the final application and harvest 4 days after. Storage followed at 45°F (7°C) and 55°F (13°C) for 7 months. 2500 ppm MH applied 4-7 weeks before harvest resulted in almost complete inhibition of sprouting at both temperatures.

The aim of this study was to investigate the effect of Maleic Hydrazide on sprouting of potato tubers, seedling length, Number of leaves. Also the effect of MH on Chlorophyll content of leaves and sugar content of tubers were also studied.

MATERIALS AND METHODS

The fresh potato tubers were collected and soaked with $HgCl_2$(0.1%) solution for 15 minutes for surface sterilization and dried for 24 hours.

Standard stock solution of 1000 ppm was prepared by dissolving 1000 mg of Maleic Hydrazide powder in one litre of distilled water. This gives 1000 ppm stock solution and from this different grades (10,50,100, 250,500 and 1000ppm) were prepared and distilled water used in case of control. These numbers of tubers constituted a set for one replication. Each was placed in respective concentration of maleic hydrazide. One set was placed in distilled water which served as the control. Then the tubers are transfered to the field after 24 hours.

Nelson-Somogiyi's reagent was prepared for quantitative estimation of both reducing and non reducing sugar of potato tubers.

RESULTS

Growth inhibitory effect of Maleic Hydrazide on potato tubers after harvest

1. Sprouting of Tubers. The same procedure was followed for the treatment of maleic hydrazide on potato tubers as done earlier for CCC. The effect of MH on sprouting of potato tubers at different concentrations (0, 10, 50, 100, 250, 500, 1000 ppm) was inhibitory. The number of sprouts was counted after 15 days of treatment of MH and this was followed after 22, 29 and 36 days. After 15 days the tubers started sprouting but the number of sprouts was low and gradually decreased with the increased concentrations of MH after 22, 29 and 36 days. MH treatment resulted in the less number of sprouts in almost all the concentrations. The mean number of sprouts after 15 days was 1.6, 1.6, 1.3, 1.0, 1.0, 0.9 and 0.6 and after 36 days it was 3.0, 3.0, 2.6, 2.3, 2.0, and 1.6 at different concentrations (Table 1).

On statistical analysis the inhibitory effect of MH emerged as highly significant. Time effect also turned out to be highly significant.

Table 1: Mean number of sprouts of potato tubers treated with MH.

Conc. of MH ppm	Time in days				Total for conc.	Mean
	15	22	29	36		
0	1.6	2.3	2.9	3.3	10.1	2.52
10	1.6	1.9	2.6	3.0	9.1	2.27
50	1.3	1.6	2.3	3.0	8.2	2.05
100	1.0	1.3	1.9	2.6	6.8	1.70
250	1.0	1.3	1.6	2.3	6.2	1.55
500	0.9	1.0	1.3	2.0	5.2	1.3
1000	0.6	0.9	1.0	1.6	4.1	1.02
Total for time	8.0	10.3	13.6	17.8		
Mean	1.14	1.47	1.94	2.54		

CD for MH (n=12) ; CD for time (n=21)
At 5% level of probability = 0.15, At 5% level of probability = 0.11,
At 1% level of probability = 0.21, At 1% level of probability = 0.14

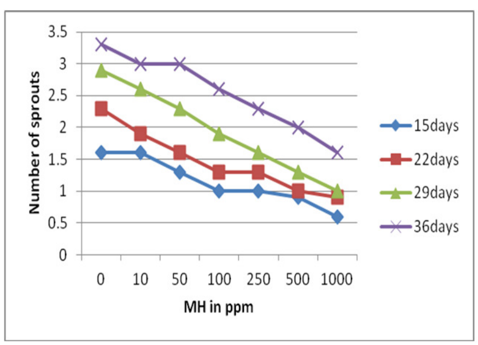

Fig. 1. Action-curves on number of sprouts.

Table 2: Analysis of variance.

Source of variance	SS	DF	MSS	F-Value
MH	6.93	7-1=6	1.15	38.33**
Time	7.76	4-1=3	2.58	86.00**
Error	0.55	3x6=18	0.03	
Total	15.24	84-1=83		

* *Significance at 1% level of probability

2. Length (cm) of seedlings. The length of the seedlings emerged from the tubers treated with MH was recorded after 15, 22, 29 and days. The mean length of the seedlings was calculated out (Table 3) and the data were analysed statistically (Table 4).

The recorded data reveal that with the increasing concentrations of MH the length of the seedlings gradually decreased (Table 3). The effect of MH was mildly inhibitory in lower concentrations and highly inhibitory at higher concentrations. At control the mean length of the seedlings was 3.3, 5.6, 6.3, 10.6 cm after 15, 22, 29 and 36 days and at 1000 ppm of MH it was 1.0, 1.9, 2.6 and 4.0 cm. Maximum reduction in shoot length was found at 1000 ppm of MH.

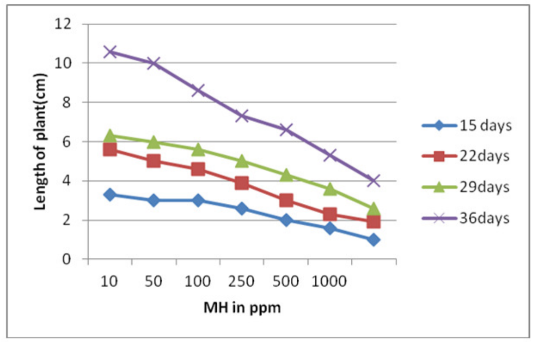

Fig. 2. Action-curves on length of plants.

Table 3: Mean length (cm) of seedlings.

Conc. of MH in ppm	Time in days				Total for conc.	Mean
	15	22	29	36		
0	3.3	5.6	6.3	10.6	25.8	6.4
10	3.0	5.0	6.0	10.0	24.0	6.0
50	3.0	4.6	5.6	8.6	21.8	5.4
100	2.6	3.9	5.0	7.3	18.8	4.7
250	2.0	3.0	4.3	6.6	15.9	3.9
500	1.6	2.3	3.6	5.3	12.8	3.2
1000	1.0	1.9	2.6	4.0	9.5	2.3
Total for time	16.5	26.3	33.4	52.4		
Mean	2.3	3.7	4.8	7.5		

CD for MH (n=12) ; CD for time (n=21)
At 5% level of probability = 0.51, At 5% level of probability = 0.36,
At 1% level of probability = 0.71, At 1% level of probability = 0.48

Table 4 : Analysis of variance.

Source of variance	SS	DF	MSS	F-Value
MH	40.5	7-1= 6	6.75	21.09**
Time	595.42	4-1= 3	198.47	620.21**
Error	5.79	3x6 =18	0.32	
Total	641.71	84-1= 83		

* *Significance at 1% level of probability

On statistical analysis the inhibitory effect of MH turned out to be highly significant.

3. Number of leaves. With the increased concentrations of MH the number of leaves also increased. The leaf numbers were counted after 15, 22, 29 and 36 days of MH treatment. At 1000 ppm of MH maximum number of leaves was recorded. The mean number of leaves after 15, 22, 29 and 36 days was 7.3, 15.0, 18.9 and 20.3 at 1000 ppm against 4.0, 9.3, 13.6 and 15.3 at control respectively (Table 5).

Table 5: Mean number of leaves.

Conc. of MH in ppm	Time in days				Total for conc.	Mean
	15	22	29	36		
0	4.0	9.3	13.6	15.3	42.2	10.6
10	5.3	10.6	14.9	16.6	47.4	11.85
50	5.6	11.6	16.3	17.6	51.1	12.7
100	6.3	12.9	17.3	18.6	55.1	13.7
250	6.9	14.0	17.9	19.0	57.8	14.4
500	7.0	14.6	18.3	19.6	59.5	14.8
1000	7.3	15.0	18.9	20.3	61.5	15.3
Total for time	42.4	88.0	117.2	127.0		
Mean	6.05	12.57	16.74	18.14		

CD for MH (n=12) ; CD for time (n=21)
At 5% level of probability = 0.52, At 5% level of probability = 0.37,
At 1% level of probability = 0.73, At 1% level of probability = 0.51

Table 6: Analysis of variance.

Source of variance	SS	D.F.	M SS	F-Value
MH	72.92	7-1=6	12.1	60.5**
Time	617.89	4-1=3	205.96	1029**
Error	3.86	3x6=18	0.2	
Total	694.49	84-1=83		

* *Significance at 1% level of probability

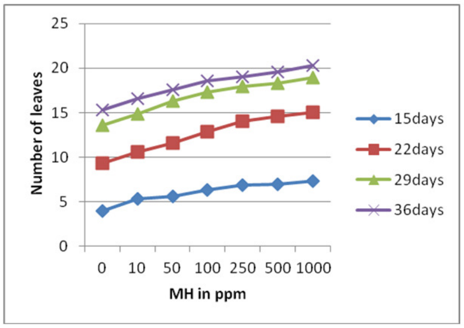

Fig. 3. Action-curves on number of leaves.

4. Chlorophyll content of the leaves. Chlorophyll content of the leaves treated with different concentrations of maleic hydrazide was estimated after 40 days of treatment following the method of Arnon (1949). The chlorophyll a content of the leaves increased with the increase of MH concentrations (Table 7). At 1000 ppm of MH chlorophyll a was 1.004 mg/g against 0.327 mg/g at control, chlorophyll b was as 1.018 mg/g against 0.396 at control and the total chlorophyll was 2.022 mg/g against 0.723 mg/g at control.

5. Estimation of sugar. The sugar content of the tubers treated with MH was estimated by Nelson-Somogyi's method. With the increasing concentrations of MH the sugar content also gradually declined from 10 to 1000 ppm (Table 8). At 1000 ppm reducing sugar was 0.03 per cent against at 0.06 per cent at control, non-reducing sugar content was 0.19 per cent against 0.38 per cent at control and total sugar content was 0.22 per cent against 0.44 per cent at control.

Table 7: Chlorophyll content of plant leaf with MH.

MH conc. in ppm	Chl a + SE (mg/g)	Chl b+ SE (mg/g)	Total Chl + SE (a+b) (mg/g)
0	0.327 + 0.002	0.396 + 0.005	0.723 + 0.007
10	0.385 + 0.003	0.437 + 0.003	0.822 + 0.006
50	0.429 + 0.001	0.516 + 0.008	0.945 + 0.009
100	0.563 + 0.005	0.674 + 0.010	1.237 + 0.015
250	0.611 + 0.003	0.775 + 0.006	1.386 + 0.009
500	0.948 + 0.007	0.991 + 0.005	1.859 + 0.012
1000	1.004 + 0.002	1.018 + 0.004	2.022 + 0.006

Table 8: Sugar content of potato tubers treated with MH.

Treatment of MH in ppm	Reducing Sugar (%) + SE	Non-reducing sugar(%) + SE	Total sugar (%) + SE
0	0.06 + 0.003	0.38 + 0.003	0.44 + 0.006
10	0.06 + 0.003	0.36 + 0.002	0.41 + 0.005
50	0.05 + 0.001	0.32 + 0.005	0.37 + 0.006
100	0.05 + 0.007	0.27 + 0.006	0.32 + 0.013
250	0.04 + 0.002	0.24 + 0.007	0.28 + 0.009
500	0.03 + 0.009	0.21 + 0.003	0.24 + 0.012
1000	0.03 + 0.005	0.19 + 0.001	0.22 + 0.006

DISCUSSION

Potato (*Solanum tuberosum* L.) is a versatile, easily available source of carbohydrate and easily digested tuber crop. In India, where the nutrition level of the population has to be maintained under inhospitable situation, the potato has a special value of food. Coleus is also an important carbohydrate and protein rich tuber crop so far not popularized in Assam. Both the tubers remain dormant for a certain period of time after harvest. This investigation was aimed at having a clear appraisal of the effect of plant growth regulators (growth promoters and growth retardants) on sprouting, vegetative growth, chlorophyll content and metabolism before and after sprouting. The experiments on sprouting and growth of the plants were conducted under laboratory conditions. Breaking of dormancy (number of sprouts), vegetative growth (length of seedlings, number of branches and leaves) chlorophyll formation and biochemical metabolism in response to applied growth regulators were assessed. Field experiments were conducted to examine plant length, number of branches, number of leaves and yield in response to treatment of plant growth regulators on coleus. The results obtained are discussed below.

Effect of MH. MH is known for its influence on plant growth and development (Schoene and Hoffman 1949). MH differs from most growth controlling chemicals in that it causes only inhibition of growth with no formative effects (Naylor and Davis 1951; Nickell, 1953).

MH treatment of potato tuber prevents sprouting and maintains the original high quality. MH checked the stimulation of sprouting of potato and coleus and resulted in the less number of sprouts in almost all the concentrations. The mean number of sprouts on potato at 1000 ppm were 0.6, 0.9, 1.0 and 1.6 against 1.6, 2.3, 2.9 and 3.3 at control after 15, 22, 29 and 36 days of treatment. In coleus, the numbers of sprouts were 3.0, 3.0, 2.6, 2.6, 2.6 and 2.3 against 3.3 at control after 36 days of treatment of at 10, 50, 100, 250, 500 and 1000 ppm of MH Cunnington (2019).

Lang (1961) observed that MH has an inhibitory effect of germination on *Carica papaya*. MH affected germination and subsequent growth of *Rumex*. Lower concentration (500 ppm) of MH also significantly retarded sprouting of carrots and onions. Gibberellic acid and MH shows significant effects on *Trifolium alexandrinum* seeds during germination (Bhatia *et al.,* 1970). *Rosa dilecta* sprayed with 0.3 per cent solution of MH were effectively inhibited.

The present findings on germination are in conformity with the earlier results of Naylor and Davis (1951) in carrot, Lang (1961) in carica, Bhatia *et al.* (1970) in trifolium.

The effect of MH on shoot elongation was highly inhibitory in all concentrations. At 1000 ppm of MH length of the plants were measured as 1.0, 1.9, 2.6 and 4.0 cm against 3.3, 5.6, 6.3 and 10.6 cm at control after 15, 22, 29 and 36 days of treatment. In coleus, the lengths of the seedlings were 2.0, 5.0, 8.6 and 10.6 cm against 3.6, 9.3, 13.6 and 16.6 cm at control after same time of interval and same concentrations. In field coleus the length of plants was 10.0, 11.9 and 18.0 cm after 40, 55 and 70 days of 1000 ppm of MH.

Seedlings are most sensitive to MH. It can inhibit growth at any stage up to maturity without killing the plant (Nooden, 1969). Dilute solutions of MH inhibited growth of tomatoes and various grasses. Stem extension of dwarf peas was inhibited by MH. At low doses MH broke apical dominance and developed side branches of peas (Brian and Hemming 1957).

The present findings of the length of seedlings are in agreement with the earlier results of Nickell (1953) in rumex, Nooden (1969) in tomatoes, Hoffmann (1949) in grass.

The mean number of leaves on potato plant was 7.3, 15.0, 18.9 and 20.3 after 15, 22, 29 and 36 days of 1000 ppm of MH treatment. In coleus, it was 7.0, 15.3, 21.0 and 22.6 at 1000 ppm at same intervals of time against 4.0, 8.6, 14.3 and 17.6 at control respectively. In field coleus, after 70 days the leaf numbers were recorded as 107.6, 115.3, 129.3, 141.3, 156.6 and 168.6 at 10, 50, 100, 250, 500 and 1000 ppm of MH against 92.6 at control. The number of branches was recorded as 25.6, 26.6, 27.3, 29.0, 30.3 and 32.6 against 24.5 at control in coleus.

David and Wayne (1952) reported that the treatment of MH on cotton reduced growth in height, number of nodes on main stem and length of vegetative branches. Application of low concentration of MH broke apical dominance and developed side branches of peas (Brian and Hemming 2008).

Brian and Hemming (2008) in peas, in that the apical growth was arrested with increased number of branches and leaves.

The chlorophyll content was maximum on potato at 1000 ppm of MH and it was estimated as: chl a 1.004 mg/g, chl b 1.018 mg/g and total chlorophyll 2.002 mg/g. In coleus at the optimal concentration of 1000 ppm the values were chlorophyll a 0.419 mg/g, chlorophyll b 0.507 mg/g and total chlorophyll 0.926 mg/g. Again, the tuber yields recorded as 103.1, 106.0, 111.5, 117.6, 122.4 and 129.1 q/ha.

MH is the only chemical that will prevent tubers left in the field at harvest from growing into volunteer plants the next year (Nooden, 1969). In addition to controlling sprouting of potato tubers, MH has been found to increase the food value and quality of tubers. MH treated tubers held at low temperatures accumulate less sugar than the non treated control. MH treated potato results in low contents of reducing sugar (Payne and Fults 1959; Yada *et al.,* 1991).

CONCLUSIONS

From the experiment, it is suggested that Maleic Hydrazide affects the growth germination of Potato tuber. Though the rate of germination is slower in MH treated tubers and the seedling length is less, the MH treated seedlings bear more leaves with high chlorophyll content as compared to controlled tubers. So, the leaves of MH treated seedlings are photosynthetically more efficient, which favours growth of the tubers and ultimately the production increases. Therefore, the application of growth retardant MH is advantageous and can be used by the cultivator of Potato tuber to increase yields.

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