THE USE OF ETHYLENE, PROPYLENE, AND SIMILAR COMPOUNDS IN BREAKING THE REST PERIOD OF TUBERS, BULBS, CUTTINGS, AND SEEDS

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(WITH ONE PLATE)

It has been known for some time that ether (**8, 4, 9**), chloroform, ethyl bromide (**1, 5**), and other substances (**6**) may be used for breaking the rest period of certain plant materials. Since the time of undertaking the study here reported, the use of ethylene for a similar purpose has been advocated by ROSA (**7**), and DENNY (**2, 3**) has published upon the applications of ethylene chlorohydrin, thiourea, potassium thiocyanate, and other substances in breaking the dormancy of potatoes. DENNY did not find ethylene or propylene especially effective in breaking the dormancy of potatoes. In this study trials of the comparative activity of ethylene, propylene, and ethylene oxide in breaking the rest period have been made with a number of seeds, tubers, bulbs, and cuttings.

Breaking the dormancy of potatoes with ethylene

In making tests of potatoes for the presence of mosaic by the tuber index method it is desirable to secure as uniform germination of the samples as possible. It is desirable to know within as short a time as possible after digging, the degree of freedom of the seed samples from mosaic diseases so that they may be judged as to grade. The potato has a rest period during which it will not sprout even if placed under favorable conditions.

Selected tubers of Early Ohio, Rural New Yorker, Bliss Triumph, Burbank Russet, Green Mountain, and Irish Cobbler were obtained from A. G. TOLAAS, in charge of the Minnesota Seed Potato Certification. The samples of these varieties were kept uniform in growth in the field and in storage conditions preliminary to trial.

The tubers were divided into four lots, and six tubers of each variety were selected for each lot, or, in other words, each lot contained six varieties of potatoes and six tubers of each variety. The tubers were carefully selected so as to have the lots as uniform in size as possible. Only those tubers free from mechanical injury and disease were used.

Lots 1 and 2 were then put into culture ovens where the temperature was maintained at 20° C. A beaker full of H_2O was set inside each oven to keep the air moist.

Lot 1 was then treated with ethylene gas, one part to one thousand by volume, while lot 2 was used as a check. At the end of thirty-six hours lot 1 received the second dose of ethylene. At the end of seventy-two hours the third dose was applied, and a fourth dose after 120 hours. The total length of treatment was six days.

A cylinder of ethylene oxide was cooled to 0° C. to liquefy it, and an aqueous solution of 1 cc. of ethylene oxide to 1,000 cc. of water was prepared. Lot 3 was soaked in this solution for twenty-four hours. Lot 4 was soaked for twenty-four hours in water. Both lots were held at room temperature.

At the end of the treatment the tubers were spread out and dried quickly by blowing a stream of warm air over the tubers. After drying, each lot was cut by means of a cork borer into pieces three-fourths of an inch in diameter. This gave a very uniform sized seed piece having an average weight of one-fourth ounce. The seed pieces were allowed to dry for two hours before planting.

Thirty seed pieces were then selected from each variety and planted in a cutting bench in the greenhouse. The seed pieces were planted in rows eight inches apart, and four inches apart within the row. Depth of planting was two inches. The soil used for planting was of the 3–2–1 mixture, light clay, sand, and leaf mold. All four lots received bottom heat, the same amount of light, and about the same quantity of water. Data were first recorded when the sprouts appeared above the surface of the ground, and at other intervals. Table I indicates the marked difference in the length of the dormancy among the various varieties as shown by the number sprouting at fifteen and forty-eight days. Evidently, the Early Ohio variety has the longest period of dormancy, followed by Rural New Yorker, Green

TABLE I

EFFECT OF ETHYLENE ON SPROUTING OF POTATO VARIETIES

VARIETY	NUMBER APPEARING ABOVE GROUND AFTER PLANTING[1]			
	15 days		48 days	
	Ethylene Lot 1[2]	Check Lot 2[3]	Ethylene Lot 1[2]	Check Lot 2[3]
Early Ohio	0	0	27	23
Rural New Yorker	2	0	28	25
Bliss Triumph	18	3	30	29
Burbank Russet	19	4	30	30
Green Mountain	4	1	29	29
Irish Cobbler	8	4	30	30

[1] 30 seed pieces of each variety were planted.

[2] Treated with ethylene 1: 1,000.

[3] Check kept in air six days.

Mountain, and Irish Cobbler. The majority of the seed pieces which received the ethylene treatment had sprouted in twenty days, except the Early Ohio. The majority of these appeared above ground in twenty-eight days after planting. In the case of lot 2 (check) a longer time was required to obtain complete sprouting, namely thirty-five days. This would indicate that the ethylene treatment speeded sprouting from seven to fifteen days.

In lot 4 the tubers soaked in H_2O for twenty-four hours required thirty-five days for complete sprouting. Hence soaking the tubers in water had no effect on dormancy. Of the tubers in lot 3 soaked in a water solution of ethylene oxide (1:1,000), only few sprouted, which indicates that ethylene oxide is very toxic. Most of the seed pieces were decayed when dug up.

In each case the ethylene-treated seed pieces, when once above the ground, grew much faster than the untreated ones. This is very clearly demonstrated by the photographs, figures 1, 2, 3, 4, 5, Plate I. The great stimulation in all of the tubers treated with ethylene is noticeable. Only one set treated with ethylene oxide is shown (table II), because most of

TABLE II

EFFECT OF ETHYLENE OXIDE ON SPROUTING OF POTATO SEED PIECES

VARIETY	NUMBER APPEARING ABOVE GROUND AFTER PLANTING[1]			
	15 days		48 days	
	Ethylene oxide Lot 3[2]	Check Lot 4[3]	Ethylene oxide Lot 3[2]	Check Lot 4[3]
Early Ohio	0	0	0	25
Rural New Yorker	1	1	1	26
Bliss Triumph	2	2	2	30
Burbank Russet	3	1	4	30
Green Mountain	0	1	2	26
Irish Cobbler	0	4	0	28

[1] 30 seed pieces of each variety were planted.

[2] Treated with ethylene oxide 1: 1,000 in water for 24 hours.

[3] Check immersed in water 24 hours.

the seed pieces rotted. Evidently this ethylene treatment will offer considerable advantage in obtaining rapid growth for the determination of tuber index for the mosaic diseases.

Treatment of corms and bulbs to break the rest period

The growing of gladiolus in greenhouses during the winter months is not a profitable business on account of the long time required for germina-

tion. For this reason only a limited amount of gladiolus is grown under glass. Commercial florists have expressed a desire for growing more gladiolus under glass if a way to treat them to shorten the length of the rest period could be found.

Forty corms of gladiolus were selected and arranged into five lots; twenty corms to lot 1 and five corms to each of the other four. The corms were carefully selected so as to be free from disease and injury, and they were as uniform in size and weight as possible. All the corms were put into air-tight glass-stoppered bottles for treatment as follows:

Lot 1. Kept in air.
Lot 2. 2 cc. of ethyl ether were added to 100 cu. inches air space.
Lot 3. 2 cc. of chloroform were added to 100 cu. inches air space.
Lot 4. Received ethylene gas, one part to one thousand parts of air.
Lot 5. Received propylene gas, one part to one thousand parts of air.

The six jars were put into a culture oven where the temperature was maintained at 20° C. After six days the corms were removed from their respective jars and planted in flats of soil.

TABLE III

EFFECT OF TREATMENT WITH ANAESTHETICS UPON SPROUTING OF GLADIOLUS

LOT	TREATMENT	NO. OF CORMS TREATED	NO. GROWING 32 DAYS AFTER PLANTING
1	Check	20	1
2	Ether	5	5
3	Chloroform	5	4
4	Ethylene	5	4
5	Propylene	5	3

As shown in table III, most of the treated corms were growing, while only one of the checks was above ground thirty-two days after planting. This experiment was repeated with a larger quantity of corms. Practically the same results were obtained. On account of the difficulty of getting larger numbers of corms of the same variety which were exactly of the same maturity, only the trial with perfectly uniform corms is reported. These experiments indicate that the dormant period of gladiolus corms was reduced by one half. It is estimated that the growth was advanced twenty-five to thirty days.

It is interesting to note that at the concentrations used ether seems to be most efficient in breaking dormancy, followed by chloroform. No differ-

ence was noted between the ethylene- and propylene-treated corms. Evidently these two homologues are about equally effective. However, the corms which received the ethylene and propylene treatment seem to grow faster than those treated with ether and chloroform, probably on account of some injury by these latter substances.

In later experiments on the larger lots the average height was determined, giving for ether- and chloroform-treated 5½ inches while the plants treated with ethylene and propylene averaged 8¼ inches tall. Ethylene oxide, concentration 1 : 1,000 was also used, but it appears to be very toxic and kills the tissues.

Dahlia tubers and cuttings of cannas were treated with ethylene 1 : 1,000. Ethylene did not seem to hasten growth in the dahlias, but it did stimulate the development of a greater number of buds on each root of cannas. On each cutting of canna which received a dose of ethylene two to four buds developed, giving two to four plants of good vigor, while the checks with few exceptions gave only one plant per cutting.

Effect of ethylene and propylene on hardwood cuttings

Hardwood cuttings of apple, plum, cherry, golden willow, red osier, lilac, alpine currant, grape, cottonwood, common elder, high bush cranberry, mock orange, honeysuckle, and pear were treated with ethylene and with propylene (1 : 1,000). Two doses were given, the second dose following forty-eight hours after the first application.

The dormancy of all of the above-mentioned twigs was broken so that leaves developed, and in the case of apple and plum flower buds also developed. There seems to be very little if any difference between ethylene and propylene in their ability to break the dormancy of buds.

Effect of ethylene and propylene on the germination of seeds

Dormant seeds of common buckthorn, high bush cranberry, snowberry, and Tartarian honeysuckle were treated with ethylene, 1 : 2,000, 1 : 1,000, 1 : 500, and 1 : 200 in air. Also propylene was used in the same concentrations. Buckthorn seeds were soaked for two minutes in concentrated H_2SO_4, washed thoroughly in H_2O, and finally washed in a two per cent. solution of sodium carbonate. These seeds were then treated for six days with ethylene 1 : 500. They gave almost a perfect germination in thirty-five days. Buckthorn seeds receiving a treatment of ethylene 1 : 500 alone showed fifty per cent. germination of the seeds in thirty-five days; slightly less than fifty per cent. germination when a concentration of 1 : 1,000 was used. Ethylene or propylene 1 : 500 for eight days in three doses gave good germination in the case of dormant seeds of high bush cranberry,

snowberry, and Tartarian honeysuckle. The use of concentration higher than 1:500 produces some injurious effects.

Conclusions

The dormancy of potato tubers varies in length, being longest in the case of Early Ohio and shortest in Bliss Triumph and Burbank Russet.

Ethylene at a concentration of one part of the gas to one thousand parts of air by volume breaks the rest period and hastens the sprouting of tubers. The time gained by such a treatment varies from seven days in the case of the Early Ohio variety to eight or nine days for Green Mountains and Rurals, to fifteen days for Burbank Russet and Bliss Triumph. The treated tubers grow faster than untreated ones. The growth stimulation by ethylene and by propylene is shown to be greater than the stimulation of ether and chloroform in gladiolus. Ethylene oxide, one part in one thousand parts of water, was toxic to potato tubers and to gladiolus. Ethylene, either alone or after treatments by sulphuric acid, is effective in securing germination of seeds of buckthorn, high bush cranberry, Tartarian honeysuckle, and snowberry. Ethylene and propylene were found about equally effective in breaking dormancy.

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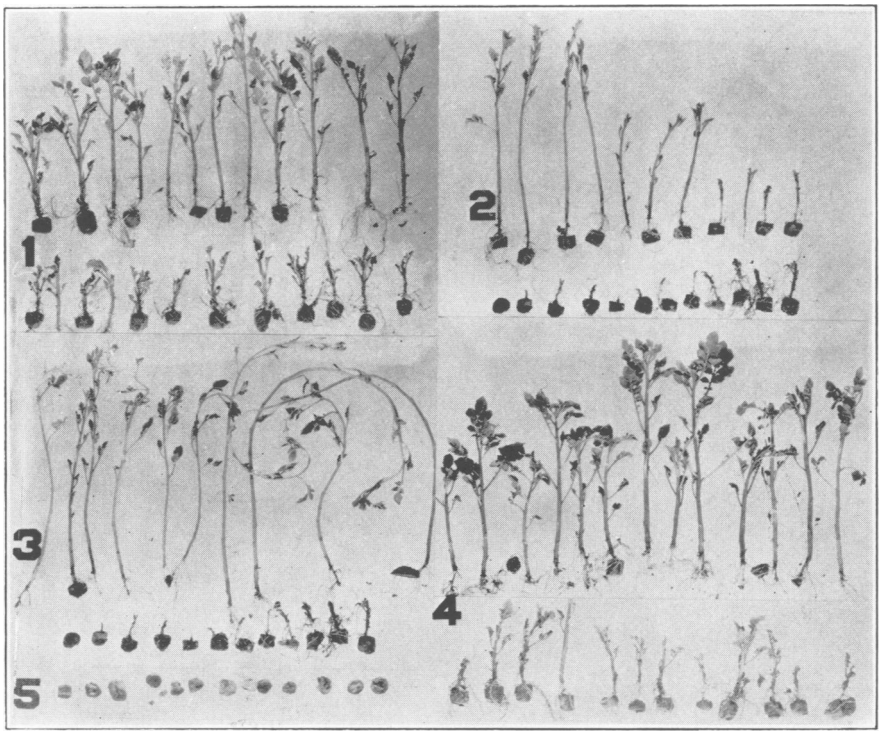

STIMULATION OF GROWTH OF POTATOES BY ETHYLENE

FIG. 1. Early Ohio. Upper row, ethylene treated; lower row, check.
FIG. 2. Green Mountain. Upper row, ethylene treated; lower row, check.
FIG. 3. Burbank Russet. Upper row, ethylene treated; lower row, check.
FIG. 4. Bliss Triumph. Upper row, ethylene treated; lower row, check.
FIG. 5. Bliss Triumph. Ethylene oxide.