CHAPTER IV
B. Effect of compounds other than auxins.

Experiment 9. **Induction of flowering and fruiting of pineapple with the aid of acetylene and calcium carbide treatments.**

**Introduction.**

Premature flowering in pineapple by smoke from wood fire was observed accidentally by the pineapple growers of Azores Island. In 1932 Rodriguez reported that ethylene and acetylene, the principal ingredients of the smoke were the cause of this enhanced flowering. His experiments in closed chamber allowing ethylene gas to gain excess in fixed volume resulted in flowering of this plant six months ahead of the untreated control plants. In later experiment acetylene also proved equally potent in this respect. Solid calcium carbide which liberates acetylene gas also behaved in an identical manner in forcing pineapples to flower prematurely. Cooper and Reese (1942) in Florida reported nearly 100% flowering by the use of continuous flow of ethylene gas adopting a method called 'trickle-system' developed by Winston, Wright and Wooten (1933). It posed, therefore, a fascinating field of research concerning flowering of plants as a whole.

The present investigation was conducted with a view to determine the potentiality of acetylene and calcium carbide in induction of early flowering and fruit formation of pineapple under the agro-climatic condition of Assam.
The whole investigation was planned in three
different sections as narrated below.

(a) Acetylene gas was allowed to flow into
water (Plate - 1) under the same pressure so that quantity
of gas released remained more or less same but with vary­
ing time interval viz. 10, 20, 30, 60, 90, 120, 150 and
200 mins. the age of the plants being almost same.

(b) Acetylene gas water thus prepared, was
applied in fixed volume of 50 ml to plants differing in
leaf number. In this operation gas flow was regulated for a
fixed interval of 10 minutes.

(c) Treatments with calcium carbide in doses
of 1 gm and 2 gms per plant to the centre of the plants were
made for convenience of comparison of efficiency with
acetylene gas water.

Field lay-out for experiment (a) is shown below.
Treatments - 1(control), 2(10 mins), 3(20 mins), 4(30 mins),
5(60 mins), 6(90 mins), 7(120 mins), 8(150 mins), 9(200 mins).

Randomised block design.

<table>
<thead>
<tr>
<th></th>
<th>R1</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>R2</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8</td>
<td>6</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>9</td>
<td>5</td>
<td>3</td>
<td>7</td>
<td>5</td>
<td>9</td>
<td>3</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>9</td>
<td>6</td>
<td>7</td>
<td>3</td>
<td>1</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

R: Randomisation.
FIG. 9

(i)

TIME INTERVAL OF GAS FLOW IN MINUTES

FLOWERING

(ii)

FLOWERING %

FRUIT WEIGHT (KG.)

LEAF NUMBER / PLANT

FLOWERING %

FRUIT WEIGHT
Plate 1. Plants showing off-season flowering following treatment with acetylene. On the left hand side the untreated plants are still remaining in vegetative stage. Samples are of the same age.

Plate 13. A sector of the field showing cent per cent forced flowering by acetylene.

Plate 14. Young plant stimulated to bear fruit by treatment with calcium carbide.

Plate 15. The youngest plant bearing only 14 leaves came to flower in response to acetylene application.
Date of plantation = 23.2.62
Date of treatment = 17.9.62
Age of the elips at the time of treatment = 1 yr. 3 months.
Number of plants per plot = 12
Total plants under treatment = 324

**Results.**

**Flower formation.** Pineapple plants were forced to
flower prematurely after 42.37 days from the date of
treatment. The very young plants, quite immature to produce
flowers in nature, also came to flower in about 9-10
months as a result of treatment with aqueous solution of
acetylene.

**Statistical analysis of the data is presented**
below.

**Analysis of variance.**

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replication</td>
<td>0.00</td>
<td>2</td>
<td>0.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>15532.20</td>
<td>8</td>
<td>1941.53</td>
<td>21.31</td>
<td>Highly</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>significant</td>
</tr>
<tr>
<td>Error</td>
<td>1457.78</td>
<td>16</td>
<td>91.11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>16989.98</td>
<td>26</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

S.E. = 5.5

C.D. at 1 % level = 43.16
C.D. at 5 % level = 31.32

The above variance table shows that acetylene
application accelerated flowering of pineapple plants quite
The relative fruit size, size of the crown and length of the peduncle in three categories of plants subjected to treatment with acetylene, calcium carbide and control (untreated).
remarkably. The C.D. values and the mean differences shown
below are also in agreement with it.

**Mean difference table.**

<table>
<thead>
<tr>
<th>Concentration</th>
<th>Control</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>60</th>
<th>90</th>
<th>120</th>
<th>150</th>
<th>200</th>
</tr>
</thead>
<tbody>
<tr>
<td>(duration in means.)</td>
<td>Mean</td>
<td>0.00</td>
<td>86.11</td>
<td>80.55</td>
<td>83.3</td>
<td>72.2</td>
<td>80.6</td>
<td>72.2</td>
<td>69.4</td>
</tr>
<tr>
<td>Mean diff.</td>
<td>86.11</td>
<td>5.56</td>
<td>2.75</td>
<td>11.1</td>
<td>8.4</td>
<td>8.4</td>
<td>2.8</td>
<td>5.5</td>
<td></td>
</tr>
</tbody>
</table>

**Fruit formation.** A marked difference in maturity
period of fruits was apparent between treated and untreated controls. Acetylene treated fruits showed early
ripening (139 days) as against 152 days that of control.
Since pineapple is a season bound short-day plant, its
flower formation occurs during its right season of the
year (Feb - March), after five months from the time of
flower formation by acetylene treated plants. The fruit
weight and size of the fruits raised from the acetylene
treated plants underwent marked reduction than that of
control. Due to treatment with acetylene the fruit weight
recorded was 1.035 Kg and volume 577.16 ml as against
1.872 Kg and 1,112.60 ml of the control.

It was also observed that the peduncle of the
fruits applied with acetylene was slender and elongated,
its length varying from 20 - 34 cms. as against 15 cms.
in untreated fruits.
Response of pineapple plants of varying age group to applied-acetylene. Plants of different age were applied with acetylene. The results observed on flowering percentage showed wide variation. Very young plants with 8 - 10 leaves could not be induced to flower, whereas those plants bearing 21 - 44 leaves rapidly came to flower, the percentage of flowering was raised to 100 percent. The untreated plants, on the other hand, still showed active vegetative growth. The other significant observation was a correlation between fruit weight and size with the number of leaves present in the treated plants. This kind of positive co-relation was observed by Van Overbeek et al (1945 -46).

The results of statistical analysis on flowering percentage is as follows.

Analysis of variance.

<table>
<thead>
<tr>
<th>Source</th>
<th>S.S.</th>
<th>df</th>
<th>M.S.S.</th>
<th>F</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replication</td>
<td>42.92</td>
<td>2</td>
<td>20.46</td>
<td>1.0</td>
<td>Not significant</td>
</tr>
<tr>
<td>Age</td>
<td>43353.74</td>
<td>7</td>
<td>6193.39</td>
<td>305.7</td>
<td>Highly significant</td>
</tr>
<tr>
<td>Error</td>
<td>283.69</td>
<td>14</td>
<td>20.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>43677.95</td>
<td>23</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

S.B. = .
C.D. at 5% level = 7.9
C.D. at 1% level = 11.0
Mean difference table.

<table>
<thead>
<tr>
<th>Leaf No per plant</th>
<th>Control 9</th>
<th>10</th>
<th>14</th>
<th>18</th>
<th>21</th>
<th>24</th>
<th>27</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean % of flowering</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>45.0</td>
<td>90.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Mean difference</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>45.0</td>
<td>45.0</td>
<td>10.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

The results of statistical analysis confirmed the variation in flowering percentage of plants of different age groups as highly significant.

Calcium carbide treatment. Similar augmentation of flowering as in the case of acetylene treatment was observed with calcium carbide application.

Overall percentage of flowering (off season) with this compound was 65.63% as against 76.40% with acetylene. The average interval from treatment to flower formation was 40.12 days and 45.10 days due to the application of 1 gm. and 2 gms. of this Ca- carbide per plant.

Fruit ripening in this case was earlier by about 7.33 days compared to control. Fruits produced after application were undersized.

Discussion.

Experimental results embodied in this thesis proved marked potentiality of acetylene in promoting flower initiation within 40 days from the date of treatment, and many months ahead of the untreated control.
plants. Premature plants with only 14 leaves otherwise too immature to produce flowers, were also forced to flower. Ripeness to flower, therefore, was markedly enhanced in consequence of acetylene treatment.

In considering the age effect, a rising trend was observed with age culminating in cent percent flowering in plants with 21 leaf number. It can be concluded that the mature plants are highly responsive to acetylene treatment than the young ones.

These findings were supported by statistical calculations which showed acetylene treatment in different doses and also in different age of the plants to be highly significant.

The induction of flowering by calcium carbide was also due to the effect of acetylene that was produced from the calcium carbide by a slow reaction with atmospheric moisture content.

These findings are in conformity with the earlier reports of Leopold (1958) that flowering in pineapple can be induced by several compounds unrelated to auxins, including hydroxyethylhydrazine, acetylene and ethylene.

The mechanism of ethylene action on flower formation is still highly speculative. There are some
evidences that pretreatment of plants with ethylene is known to decrease the levels of diffusible auxin (Guttenberg and Steinmetz, 1941; Michener, 1938; Von der Laan, 1934) as well as cell elongation (Burg and Burg, 1965 & on the other hand, 1966). The possibility exists that ethylene regulates influencing rapid auxin levels in plant tissues by affecting the synthesis of auxins (Guttenberg and Steinmetz, 1941; Burg and Burg, 1966; Michener, 1938; Morgan and Gausman, 1966 and Von der Laan, 1934). Reports pouring in the recent years appear to support the view that ethylene causes synthesis of auxin in plant tissues (Valdovinos, Leland and Henry, 1967) and this may be the real cause for greater production of flowers in auxin treated plants.

Moreover, Burg and Burg (1967) suggested a kind of triggering influence of ethylene in this regard in a wide variety of plants. They proposed that the unsaturated compounds are active. The double bond structure in the molecular configuration of ethylene is expected to confer far more activity than the one with triple bond (acetylene) whereas the single bond (ethane) had proved to be ineffective. The change of metabolic activity in plants rests mainly on the molecular size of compounds in general.

Induction of flowering by acetylene in this
experiment may best be explained in the light of the above hypothesis. The logical assumption is that it may alter the endogenous auxin level to a threshold concentration which cause flowering in this plant.

It can, therefore, be concluded that acetylene is highly potential in inducing flower formation in pineapple plants and it can induce a plant to flower in any season if it attains the minimum age required for initiation of flowering.
Pot Experiment

Experiment 10. Investigation on the influence of NAA, GA, acetlene and calcium carbide on the flowering and fruit formation of pineapples.

This experiment was designed to screen a number of auxins and allied compounds on the above aspect and comparing the results thus collected with the results under field condition.

Pots were filled with the mixture of soil and well compost cow dung in equal quantity. Slips of uniform size and weight were collected from the nursery bed and planted one in each pot after the striping off the lower dried leaves of the stem. 20 pots were allotted for each treatment. Aqueous solution of NAA and GA in one concentration (10 ppm) was applied at the stem apices in 50 ml. per plant. Acetylene-water was applied in 50 ml. per plant. For solid calcium carbide, dusting with 0.5 gm. per plant was made. Age of the plants at the time of application was 1 year 7 months. Application was done on 12.12.64. The plants were irrigated twice in a week.

Results:

Flower formation. The percentage of flower formation in potted plants was counted. 80 percent flowering was the result of solid calcium carbide application in contrast to 75 percent of acetylene. There was no sign
FIG. 10

(i)

FLOWERING %

100

60

20

A

B

(ii)

TIME INTERVAL (DAYS)

TIME INTERVAL (DAYS)

120

100

80

60

40

20

A

B

ACETYLENE

CALCIUM CARBIDE

NAA

A. POT EXPERIMENT

B. FIELD EXPERIMENT
Potted plants subjected to treatments of acetylene(19) and calcium carbide(20).
FIG.10

(iii)

FRUIT MATURITY (DAYS)

A

B

165
150
140

(iv)

FRUIT WEIGHT (KG)

A

B

ACETYLENE

CALCIUM CARBIDE

NAA

A. POT EXPERIMENT

B. FIELD EXPERIMENT
of flower induction in control and GA treated plants. NAA induced only 60% flowering. Fig.10(i) will show the results.

**Statistical analysis is shown below:**

**Analysis of variance.**

<table>
<thead>
<tr>
<th>S.S. due to</th>
<th>S.S.</th>
<th>df</th>
<th>m.S.S.</th>
<th>F</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>12360</td>
<td>4</td>
<td>3090</td>
<td>309</td>
<td>Highly significant</td>
</tr>
<tr>
<td>Error</td>
<td>90</td>
<td>5</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>12410</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

S.E. = 0.176

C.D. at 1% level = 1.05

C.D. at 5% level = 0.64

**Mean difference tables.**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Control</th>
<th>Calcium Carbide</th>
<th>NAA</th>
<th>GA</th>
<th>Acetylene</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean percent of flowering</td>
<td>0.00</td>
<td>80.00</td>
<td>60.00</td>
<td>0.00</td>
<td>75.00</td>
</tr>
<tr>
<td>Mean difference</td>
<td>80.00</td>
<td>20.00</td>
<td>60.00</td>
<td>75.00</td>
<td></td>
</tr>
</tbody>
</table>

The variance table shows that the effect of Calcium Carbide, Acetylene and NAA were highly significant in inducing flowering of pineapple plants grown in pots. GA however, proved ineffective.

**Flowering.** Flowers were visible from 12.3.65 to 27.3.65. The control and GA treated plants remained in vegetative stage still then. The flower formation took place after 100.92, 98.94 and 98.91 days from the date of
Plate 21. Untreated potted plants.

Plate 22. Treatment of potted plants with NAA at 10 ppm.
Plate 25. Treatment of potted plants with Gibberellic acid.

application of NAA, Acetylene and Calcium carbide respectively (c.f. Fig.10 -ii). Statistical analysis of time intervals needed for flowering of these three treatments samples from the date of treatment did not show any significant variation, which means plant under the treatments with these three compounds produced flower simultaneously.

**Analysis of variance.**

<table>
<thead>
<tr>
<th>Source</th>
<th>S.S.</th>
<th>df</th>
<th>m.S.S.</th>
<th>F</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>35.48</td>
<td>2</td>
<td>17.74</td>
<td></td>
<td>Not significant</td>
</tr>
<tr>
<td>Error</td>
<td>826.29</td>
<td>39</td>
<td>21.19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>861.77</td>
<td>41</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Fruit maturity.** Acetylene and Calcium carbide treatments caused early ripening showing the time intervals of 143.87 and 145.40 days respectively. NAA, on the other hand caused delay, recording 157.64 days. Analysis done on the statistical basis stands as follows:

**Analysis of variance.**

<table>
<thead>
<tr>
<th>Source</th>
<th>S.S.</th>
<th>df</th>
<th>m.S.S.</th>
<th>F</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>1411.52</td>
<td>2</td>
<td>705.76</td>
<td>14.9</td>
<td>Highly significant in delayed fruit maturity.</td>
</tr>
<tr>
<td>Error</td>
<td>2035.08</td>
<td>43</td>
<td>47.33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3446.60</td>
<td>45</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

S.E. = 1.8
C.D. at 1% level = 7.01
C.D. at 5% level = 5.21

**Mean of different treatment.**

NAA = 157.64
Acetylene = 145.87
Calcium carbide = 145.40
Statistical analysis showed the effect of these three chemicals as highly significant in causing early fruit ripening.

**Fruit weight.** No marked variation was noticed in this score. The average weights were 1.061, 1.090 and 1.107 Kg. for Acetylene, Calcium carbide and NAA treatment respectively.

Statistical analysis stands as follows:

**Analysis of variance.**

<table>
<thead>
<tr>
<th>Source</th>
<th>S.S. due to</th>
<th>df</th>
<th>m.s.s.</th>
<th>( P )</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>.008</td>
<td>2</td>
<td>.004</td>
<td></td>
<td>Not significant</td>
</tr>
<tr>
<td>Error</td>
<td>.302</td>
<td>42</td>
<td>.007</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>.310</td>
<td>44</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The table shows that there was no significant variation in the weights of fruits even after the application of Acetylene, Calcium carbide and NAA.

Similar trends were observed on the number of fruitlet and length of peduncles as a result of the application of these three chemicals. Only calcium carbide and Acetylene treated plants produced 1-3 slips per plant (plate -24 & 25). Fig.10( 1 - iv ) will show the comparison between the results of field( Experiments 9 and 12 of these thesis ) and pot experiments.
Discussion.

It is thus observed that Calcium carbide, acetylene and NAA are the compounds highly potent in inducing early flowering in pot grown pineapple plants as in the case of field experiments. The difference of results in respect to flower formation under two conditions lies in reduction of flower number in pot experiments compared to those under field condition. While for potted plants the flowering percentages were 80.00, 60.00 and 75.00, that for plants grown in field showed 81.25, 85.19 and 86.11 as a result of application with Calcium carbide, NAA and acetylene.

Fruit ripening was delayed by NAA with its high concentrations.

This experiment furnishes further information that the potency of NAA appears to decline to some extent under pot culture condition.

All these lend support to the conclusion that the response of plants towards auxin and other growth regulators varies with the conditions under which the plants are grown.