PART IV

EXPERIMENTAL CULTIVATION
EXPERIMENTAL CULTIVATION

EXPERIMENTAL PROCEDURE AND RESULTS

Experimental cultivation of V. anthelmintica was conducted at the experimental garden of the University of Calcutta. The first lot of seed was collected from a local dealer in March, 1967. A piece of land at the experimental garden was divided into a number of subplots in which healthy seeds of predetermined viability were broadcast. Prior to broadcasting, nitrogen, potassium, phosphorus content and pH of the soil were determined (Table LI).

Table LI
Soil analysis

<table>
<thead>
<tr>
<th>Observation</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH by glass electrode</td>
<td>7.86</td>
</tr>
<tr>
<td>Nitrogen content (dry basis)</td>
<td>0.06%</td>
</tr>
<tr>
<td>Potassium content (&quot; )</td>
<td>0.04%</td>
</tr>
<tr>
<td>Phosphorus content (&quot; ) as P$_2$O$_5$</td>
<td>0.21%</td>
</tr>
</tbody>
</table>

Meteorological observations (Tables, LII and LIII) during the period of cultivation were also recorded to study the seasonal influence on growth of plants and seed yield.
### Table LII

Meteorological data - 1967 and 1968
(Recorded at Chinsurah Rice Research Station, W. Bengal)

<table>
<thead>
<tr>
<th>Month</th>
<th>1967 Monthly average</th>
<th>1968 Monthly average</th>
<th>Total rainfall (in mm)</th>
<th>1967 Monthly average</th>
<th>1968 Monthly average</th>
<th>Total rainfall (in mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>max. temp. (°C)</td>
<td>min. temp. (°C)</td>
<td>(in mm)</td>
<td>max. temp. (°C)</td>
<td>min. temp. (°C)</td>
<td>(in mm)</td>
</tr>
<tr>
<td>January</td>
<td>24.9</td>
<td>10.7</td>
<td>75.0</td>
<td>25.3</td>
<td>9.2</td>
<td>0.0</td>
</tr>
<tr>
<td>February</td>
<td>30.3</td>
<td>12.7</td>
<td>0.0</td>
<td>27.9</td>
<td>11.2</td>
<td>31.5</td>
</tr>
<tr>
<td>March</td>
<td>31.5</td>
<td>18.1</td>
<td>31.0</td>
<td>34.4</td>
<td>17.7</td>
<td>20.3</td>
</tr>
<tr>
<td>April</td>
<td>35.8</td>
<td>20.5</td>
<td>77.3</td>
<td>36.4</td>
<td>22.1</td>
<td>25.3</td>
</tr>
<tr>
<td>May</td>
<td>36.7</td>
<td>24.4</td>
<td>136.5</td>
<td>37.9</td>
<td>24.5</td>
<td>69.2</td>
</tr>
<tr>
<td>June</td>
<td>35.4</td>
<td>25.0</td>
<td>44.7</td>
<td>31.7</td>
<td>23.5</td>
<td>423.4</td>
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<td>July</td>
<td>31.9</td>
<td>24.4</td>
<td>253.8</td>
<td>31.3</td>
<td>24.6</td>
<td>450.5</td>
</tr>
<tr>
<td>August</td>
<td>31.2</td>
<td>24.5</td>
<td>346.8</td>
<td>31.3</td>
<td>24.1</td>
<td>255.0</td>
</tr>
<tr>
<td>September</td>
<td>31.6</td>
<td>24.2</td>
<td>231.8</td>
<td>32.7</td>
<td>24.5</td>
<td>54.2</td>
</tr>
<tr>
<td>October</td>
<td>31.5</td>
<td>20.2</td>
<td>36.1</td>
<td>30.7</td>
<td>20.5</td>
<td>160.3</td>
</tr>
<tr>
<td>November</td>
<td>28.9</td>
<td>12.7</td>
<td>0.0</td>
<td>27.9</td>
<td>13.8</td>
<td>47.2</td>
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<tr>
<td>December</td>
<td>27.0</td>
<td>11.9</td>
<td>0.0</td>
<td>25.5</td>
<td>10.2</td>
<td>0.0</td>
</tr>
<tr>
<td>Month</td>
<td>1969 Monthly average max temp. (°C)</td>
<td>1969 Monthly average min temp. (°C)</td>
<td>1969 Total rainfall (in mm)</td>
<td>1970 Monthly average max temp. (°C)</td>
<td>1970 Monthly average min temp. (°C)</td>
<td>1970 Total rainfall (in mm)</td>
</tr>
<tr>
<td>---------</td>
<td>-----------------------------------</td>
<td>-----------------------------------</td>
<td>---------------------------</td>
<td>-----------------------------------</td>
<td>-----------------------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>January</td>
<td>25.5</td>
<td>10.5</td>
<td>5.6</td>
<td>25.0</td>
<td>10.3</td>
<td>32.2</td>
</tr>
<tr>
<td>February</td>
<td>29.8</td>
<td>13.3</td>
<td>4.6</td>
<td>30.6</td>
<td>14.5</td>
<td>0.0</td>
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<tr>
<td>March</td>
<td>34.8</td>
<td>20.4</td>
<td>56.6</td>
<td>34.6</td>
<td>18.2</td>
<td>13.2</td>
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<td>36.5</td>
<td>12.2</td>
<td>42.0</td>
<td>38.6</td>
<td>24.3</td>
<td>9.1</td>
</tr>
<tr>
<td>May</td>
<td>34.9</td>
<td>23.2</td>
<td>159.4</td>
<td>38.9</td>
<td>26.9</td>
<td>10.9</td>
</tr>
<tr>
<td>June</td>
<td>34.5</td>
<td>24.5</td>
<td>153.0</td>
<td>33.3</td>
<td>26.4</td>
<td>377.6</td>
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<tr>
<td>July</td>
<td>31.8</td>
<td>24.9</td>
<td>227.7</td>
<td>32.6</td>
<td>26.3</td>
<td>100.5</td>
</tr>
<tr>
<td>August</td>
<td>30.7</td>
<td>24.6</td>
<td>385.7</td>
<td>31.8</td>
<td>26.2</td>
<td>194.1</td>
</tr>
<tr>
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<td>31.0</td>
<td>24.7</td>
<td>335.3</td>
<td>31.7</td>
<td>25.1</td>
<td>142.6</td>
</tr>
<tr>
<td>October</td>
<td>31.1</td>
<td>21.1</td>
<td>29.6</td>
<td>30.9</td>
<td>21.8</td>
<td>139.8</td>
</tr>
<tr>
<td>November</td>
<td>29.5</td>
<td>14.4</td>
<td>10.0</td>
<td>29.7</td>
<td>17.7</td>
<td>23.1</td>
</tr>
<tr>
<td>December</td>
<td>25.5</td>
<td>10.6</td>
<td>0.1</td>
<td>25.4</td>
<td>9.9</td>
<td>5.6</td>
</tr>
</tbody>
</table>

Table LIII

Meteorological data - 1969 and 1970
(Recorded at Chinsurah Rice Research Station, W. Bengal)
Experimental cultivation was initiated in 1967 and it was continued in the succeeding years by growing plant from the seeds harvested in the previous year.

Experiments on cultivation were designed mainly to have an idea on the growth of plants, seed yield and characteristics of the seed lipid by growing the plants under the influence of the following conditions:

1. Cultivation in three different seasons of the year.
2. Influence of gibberellic acid (GA).
3. Application of inorganic fertilizers containing nitrogen, potassium and phosphorus.

1. Seasonal influence:

Plants were cultivated in three different seasons of year viz., summer, wet season and winter, mainly to determine the most suitable period for cultivation as well as to observe the effect of the seasons specially on the growth characteristics, seed and lipid yield. In 1967, plants were cultivated in late July (wet or rainy season) and in late November at the onset of winter. Seeds were broadcast on properly dressed soil in different sub-plots and about one month after sprouting ten plants in each sub-plot were marked at random for recording growth data, seed yield and other observations. The experiment was repeated in the following year in the same respective seasons.
Over and above this, in 1969 and 1970 experimental cultivation was continued similarly in March at the commencement of summer.

Result:

Cultivation in different seasons indicated that the variation in the climatic condition influenced largely the growth and development of the plants (Table, LIV). Seeds germinated within four and six days when sown in wet season and summer respectively, but in winter 12-14 days lapsed before most of the seeds sprouted. The percentage of germination within the aforesaid periods were 66 and 69 in summer and rainy season while the rate dropped to 46% in winter. Plants cultivated in rainy season needed 113 to 115 days to complete their lifecycle, while the winter cultivation prolonged it to 120 to 125 days and the summer one shortened it (90-95 days). A luxuriant growth of plants was observed mainly in wet season (90.0 cm). The summer plants were shorter (72.8 cm) and those of winter had very stunted growth (52.8 cm). Average seed yield per plant in rainy season was 1.64 gm. Yield decreased to 1.26 gm and 0.5 gm in winter and summer respectively.

2. Influence of gibberellic acid:

Cultivation of the plants under the influence of gibberellic acid (GA₃) was started in 1968 in the rainy season. Plants of certain sub-plots were treated with gibberellic acid of two different concentrations, viz., 100 ppm and 500 ppm in aqueous
solution. The solutions were first applied on seedling by foliar spraying on the 10 day after sprouting and spraying was continued at every fortnight till the initiation of flowering. Height of the plants, which were marked at random previously in each treated block, was recorded on every 15 day upto the flowering stage. The seeds after maturation were collected in separate packets from the marked plants to record the yield data.

The analytical experiments with the collected seeds were based on the study of lipid characteristics including oil content in the seed and fatty acid content in seed lipid. The experiment was repeated under identical conditions in 1969.

Result:

Foliar spraying of gibberellic acid on plants cultivated in wet season favoured luxuriant vegetative growth (Fig.15) and increased seed yield over the untreated ones (Table,LIV). Plants treated with solutions containing 500 ppm and 100 ppm of GA attained an average height of 135.0 cm and 123.0 cm respectively just before flowering (Fig.16). Seed yield per plant increased from 1.64 gm to 2.87 gm (in 100 ppm GA). GA 500 ppm produced 2.35 gm of seed per plant. Other observations regarding germination in field and life cycle under these treatments were similar as observed in untreated plants cultivated in rainy season.
## Table LIV

Phenological observations on germination behaviour, growth and lipid characteristics

<table>
<thead>
<tr>
<th>Observations</th>
<th>Summer (March-June)</th>
<th>Rainy season (July-November)</th>
<th>Winter (Nov. - March)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date of sowing</td>
<td>2. 3. 69 &amp; &amp; 1. 3. 70</td>
<td>22. 7. 67 &amp; 26. 7. 68 &amp; 25. 11. 68</td>
<td>24. 11. 67 &amp; &amp; 25. 11. 68</td>
</tr>
<tr>
<td>No. of days taken to germinate (av. of 2 yrs.)</td>
<td>5 - 6 &amp; 4 &amp; 12 - 14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approx. no. of days from sowing to first harvest</td>
<td>90 - 95 &amp; 113-115 &amp; 120 - 125</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Av. height of plants (av. of 2 yrs.)</td>
<td>72.8 cm &amp; 90.0 cm &amp; 52.8 cm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Healthy seeds per plant (av. of 2 yrs.)</td>
<td>0.5 gm &amp; 1.64 gm &amp; 1.26 gm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Lipid characteristics:**

- **Oil content in seeds as % dry wt. (av. of 2 yrs.)**
  - Summer: 23.0, Rainy season: 23.1, Winter: 22.9
- **Oleic acid (av. of 2 yrs.)**
  - Summer: 3.8, Rainy season: 4.0, Winter: 5.1
- **Epoxyoleic acid (av. of 2 yrs.)**
  - Summer: 69.5, Rainy season: 72.2, Winter: 68.5
- **Linoleic acid (av. of 2 yrs.)**
  - Summer: 16.3, Rainy season: 13.9, Winter: 15.6
- **Dihydroxyoleic and linolcic acid (av. of 2 yrs.)**
  - Summer: 1.0, Rainy season: 0.5, Winter: 0.5
- **Saturated acids (by diff.)(av. of 3 yrs.)**
Fig. 16. Height of plants sprayed with GA
Fig. 15. Growth of plants under the influence of GA.

Fig. 17.

TLC on silica gel G of the seed lipid.
GA100 and GA500 represent oil from seeds treated with 100 ppm and 500 ppm GA respectively.
Solvent system: (v/v)
Petroleum : Diethyl ether : Acetic acid
70 : 30 : 0.5
Visualization by charring with 50% sulphuric acid.
Dry seeds contain about 23 per cent oil. Plants grown in the rainy season were regarded as control in respect to those cultivated under other conditions. There was little variation in lipid content in seeds obtained from plants cultivated either in summer and winter seasons or under GA treatments. The fatty acid content in oil of the seeds under these treatments also did not show any appreciable change. The characteristics of the seed lipids have been presented in Tables, LIV and LV and Fig.17. Under the aforesaid conditions epoxy-oleic acid content varied from 68.5 to 72.3 per cent. Similarly, linolenic acid, oleic acid, dihydroxyoleic acid and linoleic acid, and saturated acid content varied from 13.9 to 16.3 per cent, 3.8 to 5.1 per cent, 0.5 to 1.0 per cent and 8.1 to 9.4 per cent respectively.

3. Application of N, P, K fertilizers:

Apart from regular cultivation in the sub-plots, studies were made in 1970 and 1971 on effect of different combinations of inorganic fertilizers containing N, P and K on the plant growth and seed yield. Nitrogen and potassium (obtained from ammonium sulphate and potassium chloride respectively) were applied as top dressing in two split doses during the active vegetative phase at an interval of 15 days. Phosphorus was applied in soil as basal dose in the form of superphosphate before broadcasting of the seeds. The plots were arranged.
<table>
<thead>
<tr>
<th>Observations</th>
<th>Control</th>
<th>GA 100 ppm</th>
<th>GA 500 ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date of sowing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of days taken to germinate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage of germination</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approx. no. of days to complete</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>life cycle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Av. height of plants (av. of 2 yrs.)</td>
<td>90.0 cm</td>
<td>123.0 cm</td>
<td>135.0 cm</td>
</tr>
<tr>
<td>Healthy seeds per plant (av. of 2 yrs.)</td>
<td>1.64 gm</td>
<td>2.87 gm</td>
<td>2.35 gm</td>
</tr>
<tr>
<td>Lipid characteristics:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil content in seed as % dry wt. (av. of 2 yrs.)</td>
<td>23.1</td>
<td>22.6</td>
<td>21.8</td>
</tr>
<tr>
<td>Oleic acid (av. of 2 yrs.)</td>
<td>4.0</td>
<td>4.1</td>
<td>3.9</td>
</tr>
<tr>
<td>Epoxyoleic acid (av. of 2 yrs.)</td>
<td>72.2</td>
<td>72.3</td>
<td>72.9</td>
</tr>
<tr>
<td>Linoleic acid (av. of 2 yrs.)</td>
<td>13.9</td>
<td>14.5</td>
<td>14.6</td>
</tr>
<tr>
<td>Dihydroxyoleic acid and linolenic acid</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>saturated acids (by diff.) (av. of 3 yrs.)</td>
<td>9.4</td>
<td>8.6</td>
<td>8.1</td>
</tr>
</tbody>
</table>

Similar as in Table LIV (Rainy season cultivation)
according to random block design and plants were grown under two sets of fertilizer combinations in 1970 and 1971 respectively.

In experiments undertaken in 1970 the following combinations of fertilizers with three replicates were used.

**Combination I applied in 1970**

\[
\begin{align*}
\text{Combination I applied in 1970} \\
N_{34} & K_{34} & P_{34} \\
N_{34} & K_{68} & P_{34} \\
N_{68} & K_{34} & P_{34} \\
N_{68} & K_{68} & P_{34}
\end{align*}
\]

* subscripts indicate kg/hectare.

In another set of sub-plots in 1971 the proportions of N and K were increased to ascertain mainly the effect of heavy fertilizers on seed yield, lipid content of the seeds and epoxyoleic acid content in seed lipid. The fertilizers in this set of experiment were used in the following combinations with three replications for each. The figures used in both the sets of combinations indicate kg per hectare.

**Combination II applied in 1971**

\[
\begin{align*}
\text{Combination II applied in 1971} \\
N_{68} & K_{68} & P_{34} \\
N_{68} & K_{102} & P_{34} \\
N_{102} & K_{68} & P_{34} \\
N_{102} & K_{102} & P_{34}
\end{align*}
\]
LAYOUT OF EXPERIMENTAL PLOT

Area of each plot = (2.337 m x 2.337 m)

<table>
<thead>
<tr>
<th>Plot number</th>
<th>Fertilizer combination for 1978</th>
<th>Fertilizer combination for 1979</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 2, 3</td>
<td>N₃₄ K₆₈ P₃₄</td>
<td>N₆₈ K₆₈ F₃₄</td>
</tr>
<tr>
<td>4, 5, 6</td>
<td>N₃₄ K₆₈ P₃₄</td>
<td>N₆₈ K₁₀₂ P₃₄</td>
</tr>
<tr>
<td>7, 8, 9</td>
<td>N₆₈ K₃₄ P₃₄</td>
<td>N₁₀₂ K₆₈ P₃₄</td>
</tr>
<tr>
<td>10, 11, 12</td>
<td>N₆₈ K₆₈ P₃₄</td>
<td>N₁₀₂ K₁₀₂ P₃₄</td>
</tr>
</tbody>
</table>
In each sub-plot ten plants were marked at random for recording yield data and collection of seed samples. Mature seeds were collected in separate packets from the marked plants growing in every treated block and the total seed yield per sub-plot was also noted. After harvesting has been complete seeds from each treated sub-plot were subjected to chemical analysis mainly to study the characteristics of the seed lipid.

The amount of seeds obtained from the plants growing at the marginal rows of each sub-plot was not taken into consideration while recording the total seed yield per sub-plot.

Result:

Application NPK fertilizers helped a good deal in increasing the production of seed. Average seed yield per plant increased in higher level of nitrogen and potassium (Fig. 18). Application of N$_{68}$K$_{102}$P$_{34}$ combination was found to be most effective when the average seed yield per plant was 8.02 gm. Yield was 3.55 gm per plant when both N and K were applied at the rate of 34 kg per hectare. In increase in the proportion of K (N$_{34}$K$_{68}$P$_{34}$) increased seed yield (4.93 gm), but such increase in the proportion of N (N$_{68}$K$_{34}$P$_{34}$ and N$_{102}$K$_{68}$P$_{34}$) was not beneficial in that respect. However, yield per plant increased considerably when both N and K were at 68 kg/hectare, or even a greater amount of K was supplied. Heavier amount of fertilizer (N$_{102}$K$_{102}$P$_{34}$) decreased the productivity per plant to some extent (7.2 gm) when compared with the N$_{68}$K$_{102}$P$_{34}$ combination.
FIG. 18. SEED YIELD PER PLANT

AVERAGE GRAIN YIELD (gms.) / Plant

TREATMENT

CONTROL

GA 100 ppm

GA 500 ppm

N34 K34

N34 K68

N68 K34

N68 K68

N102 K102

N102 K68

FIG. 18. SEED YIELD PER PLANT
The average grain yield per unit land area eventually revealed a similar picture as presented by the average production per plant. Yield per square meter of land area increased in the higher level of nitrogen in combination with higher dose of potassium. The grain yield decreased in the higher N-level in combination with lower K dose. Figure 19 indicating the total grain yield per square meter of land area in the different manurial combinations and also in the different doses of GA, shows that the grain yield was always greater in the higher doses of fertilizers than in the higher doses of GA or in the control. Untreated plants produced 105.1 gm/m² land area (= 105.1 kg/hectare). Similarly, production under GA 100 ppm and GA 500 ppm were 183.88 gm and 159.80 gm respectively. Under the fertilizer trials the highest amount of seed was obtained by N₆₈K₁₀₂P₃₄ combination when average yield per square metre land area was 514.1 gm (= 514 kg/hectare).

The chemical characteristics of the oil in seeds collected from plants cultivated under four different doses of fertilizers have been presented in Table, LVI. Oil content in seed regardless of the treatments varied from 22.6 to 23.7 per cent. Similarly epoxyoleic acid content in the oil and acid value of the seed lipid showed no significant change in response to application of heavy fertilizer. Epoxyoleic acid content lay between 69.5 to 70.9 per cent and the acid value extended from 2.6 to 2.8, both of which were closely associated with the values obtained from analysis of untreated samples. Application of NPK fertilizers in combination failed either to increase lipid content in the seed or the epoxy content in the seed lipid.
Table LVI

Effect of NPK fertilizer on seed lipid

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Lipid content %</th>
<th>Epoxy value (as epoxyoleic acid)</th>
<th>Acid value</th>
</tr>
</thead>
<tbody>
<tr>
<td>N(<em>{68}) K(</em>{68}) P(_{34})</td>
<td>23.7</td>
<td>70.2</td>
<td>2.6</td>
</tr>
<tr>
<td>N(<em>{68}) K(</em>{102}) P(_{34})</td>
<td>23.1</td>
<td>69.8</td>
<td>2.8</td>
</tr>
<tr>
<td>N(<em>{102}) K(</em>{68}) P(_{34})</td>
<td>22.6</td>
<td>69.5</td>
<td>2.7</td>
</tr>
<tr>
<td>N(<em>{102}) K(</em>{102}) P(_{34})</td>
<td>22.7</td>
<td>70.9</td>
<td>2.6</td>
</tr>
</tbody>
</table>
FIG. 19. SEED YIELD PER METER SQUARE LAND AREA (EQ KG/HECTARE)

AVERAGE GRAIN YIELD (gms.)/m^2 Land area

TREATMENT

CONTROL  G_A 100 ppm  G_A 500 ppm  N_34 K_34  N_34 K_68  N_68 K_34  N_68 K_68  N_68 K_102  N_102 K_102

FIG. 19. SEED YIELD PER METER SQUARE LAND AREA (EQ KG/HECTARE)
DISCUSSION

*Vernonia anthelmintica* grows throughout India as a common wild species and is generally abundant in fields used for cultivating other seasonal crops. The plant is well known in India for a long time mostly for its medicinal value. Occurrence of epoxyoleic acid, a naturally epoxidized material, in its seed oil has in recent years further increased the importance of cultivation of this crop as a potential source of the particular fatty acid. Cultivation of this crop has been practised from different aspects in U.S.A. particularly, but few reports are available regarding cultivation in India with local varieties.

The present study indicate that seasonal variation has got profound effect on the growth and development of the plants. Normally seeds are sown in June-July (Chopra *et al*, 1962) when rainfall is very high in this part of the country (Tables LII and LIII). During this rainy season germination is quicker in soil and the rate of germination is also higher than those seeds sown in summer or winter (Table LIV). It is supposed that the amount of rainfall is correlated with the germination of the seeds which contains endogenous inhibitor. Heavy showers facilitate leaching of seeds in soil and subsequent removal of the substance from the surrounding medium. The warm and humid atmosphere may also favour the activity of soil organisms which
help in decaying of the seed coat ensuring better penetration of water and gases. Such regulatory mechanism connected with rainfall has been described by Soriano (1953a) for *Baeeria chrysostoma*. The vegetative growth and yield of seed are also favoured by rainy season, whereas plants in winter or summer (having low precipitation) have hindered growth and poorer yield.

Cultivation in both summer and winter is not beneficial from economic point of view. Summer plants are unable to thrive in hot atmosphere and die earlier with only few healthy flowers, and thus seed yield is very poor. Vegetative growth of plants cultivated in winter is checked by early flowering. The findings are consistent with Higgins' observation (1968). The plants live longer in colder climate but the seed yield is lower than the rainy season crop as the number of flowers in plants are fewer. Planting and harvesting dates are of importance primarily as they influence seed maturity (Higgins and White, 1968). Higgins (1968) reported that the optimum harvest period was found to be September 15th to October 1st with seeds sown in May 1st to May 18th. The present observations suggest that in this part of India planting of the seeds are suitable in July for a better production of seeds. The overall production when expressed in kg/hectare has been observed very low (Fig.18) when other workers have reported much higher amount of seed production (Lessman and Berry, 1966; Massy, 1967;
Higgins, 1968). Such a difference in seed yield may be for varietal difference.

Foliar spraying of gibberellic acid on plants of rainy season favours luxuriant vegetative growth (Fig. 15). Seed yield per plant also increases over the untreated ones (Table, LV). One of the most significant developmental effects is the ability of gibberellin to cause certain plants to flower, i.e., to cause the conversion of vegetative apices into flowering apices (Cleland, 1969). The gibberellin level also regulates the mitotic activity of the sub-apical meristem (Sachs et al., 1959). Thus in Vernonia spraying with GA solution favoured branching of stem and induced flower formation, both of which ultimately helped in increasing seed yield over control. GA in 100 ppm solution has been found to be more effective in seed production than 500 ppm level. Under the higher level excessive vegetative growth has probably affected the reproductive growth and thus seed yield is not favoured further. In this species Tewari et al., (1968) obtained increased seed yield by 22, 14 and 26 per cent with 75 ppm solution of Indole-3-acetic acid, Indole-3-butyric acid and α-naphthyl acetic acid respectively, sprayed before flower emergence. Application of GA at 100 ppm concentration increases seed yield appreciably in this experimental cultivation. Untreated plants produced 105.1 kg seed per hectare whereas production under GA 100 ppm and 500 ppm level where 183.88 kg and 159.80 kg respectively (Fig. 19).
The lipid yield and fatty acid composition of the fats extracted from the seeds harvested in three different seasons and also from GA treated plants are almost identical with those of the seeds prior to broadcasting (Tables, VI and VII). In pea plants application of GA induces changes in concentration of tissue lipids (Norcia et al., 1964). But in Vernonia seasonal variation or treatment with GA do not appear to have any significant influence on the biosynthetic sequence of lipids (Fig. 17).

Chemical fertilizers containing nitrogen, potassium and phosphorus have been found to be more effective than GA in enhancing seed production. Under fertilizer trials, the highest amount of seed has been obtained with \( \text{N}_6\text{K}_{10}\text{P}_{34} \) combination when average yield per plant is 8.02 gm showing about 5 times increase over control. Figures 18 and 19 present a comparative picture of yield data both under GA and fertilizer trials. But actually under every treatment production of seed per plant is much higher as a large quantity of seed is lost during harvest. The main problems associated with its production are a tendency for the seeds to shatter and indeterminate fruiting habit, which results in the seed ripening over a 6 week period (Massey, 1968).

From the different combination of nitrogen and potassium in fertilizer trials it is observed that an increase in the proportion of K enhances seed yield but such increase in the proportion of N is not beneficial in that respect. Both nitrogen
and potassium favour growth and yield in plants. In cereals, potassium can antagonise the influence brought about by heavy nitrogen application, viz., reversal of nitrogen induced elongation in length and decrease in weight per unit length of culm (Srivastava and Yawalkar, 1960). The effectiveness of potassium in giving strength to straw in cereals in order to reduce lodging has been emphasized by several workers (Nightingale, 1943; Boswell and Parks, 1957; Burkersroda, 1964; Mukherjee et al., 1968). In *Vernonia* both nitrogen and potassium favour vegetative growth and seed yield, but to obtain maximum benefit a balanced combination is needed. However, yield per plant increases considerably when both N and K are applied at 68 kg/hectare, or even a greater amount of K is supplied. The highest amount of seed has been produced by $N_{68}K_{102}P_{34}$ combination when average yield per sq. meter land area is 514.1 gm (= 514.1 kg/hectare). Production of about 800 kg/hecate with 102 kg of N/hectare is reported by Lessman and Berry (1966) who in some other trials obtained even 1566 kg of seed per hectare. In the present variety of *Vernonia* a further increase in supply of N and K in combination ($N_{102}K_{102}P_{34}$) has no beneficial effect on yield as according to some workers (Boswell and Parks, 1957; Burkersroda, 1964) this is an evidence of 'luxury consumption'.

The oil content and the chemical characteristics of the oil in seeds collected from plants under four different combi-
nation of fertilizers show no significant change from the values obtained from analysis of untreated samples (Tables LV and LVI). Oil content of seeds remains near about 23 per cent and similarly epoxyoleic acid content in oil is nearly 70 per cent. The experiment with fertilizer trials indicate that NKP in different combinations fail either to increase lipid content in the seed or the epoxy content in seed lipid. The only point of interest and importance in the case of application of inorganic fertilizers on plants grown in rainy season is a net higher yield of seeds and hence of lipid (also epoxyoleic acid) per plant.