CHAPTER 3

MATERIALS AND METHODS

A field experiment was conducted during 2005-06 and 2006-07 to assess the influence of chemical N and biofertilizers and their combination to supplement the nitrogen needed in late sown wheat-maize sequence. The details of the materials used and the methodology adopted during the course of investigation have been described in this chapter.

3.1. LOCATION

The field experiment was carried out at the Research Farm of A.S. (P.G.) College, Lakhaoti (Bulandshahr), situated at 28.4°N latitude, 77.1°E longitude and at an elevation of 228.6 m above mean sea level.

3.2. SOIL CHARACTERISTICS

Prior to the initiation of the experiment, a composite soil sample was collected to a depth of 0-15 cm by using soil auger from the experimental site. The sample was analysed for physico-chemical properties and the details are given in Table 1.

The soil was sandy loam, well drained, low in organic carbon and available nitrogen but medium in available phosphorus and potassium content. The soil pH was neutral but had a slight alkaline tendency.
Table 1. Physico-chemical properties of the soil.

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Methods employed</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Physical characteristics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Soil separates (%)</td>
<td>(Bouyoucos, 1962)</td>
<td></td>
</tr>
<tr>
<td>Sand</td>
<td></td>
<td>66.3</td>
</tr>
<tr>
<td>Silt</td>
<td></td>
<td>15.1</td>
</tr>
<tr>
<td>Clay</td>
<td></td>
<td>18.6</td>
</tr>
<tr>
<td>2. Textural class</td>
<td>Sandy loam</td>
<td></td>
</tr>
<tr>
<td>3. Bulk density (g/cc)</td>
<td>Piper (1950)</td>
<td>1.51</td>
</tr>
<tr>
<td><strong>B. Chemical characteristics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. pH (1:2.5; soil:water)</td>
<td>By glass electrode</td>
<td>7.6</td>
</tr>
<tr>
<td></td>
<td>pH meter</td>
<td></td>
</tr>
<tr>
<td>2. EC (ds/m at 25°C)</td>
<td>Piper (1950)</td>
<td>0.29</td>
</tr>
<tr>
<td></td>
<td>(Solubridge method)</td>
<td></td>
</tr>
<tr>
<td>3. Organic carbon (%)</td>
<td>Walkley and Black</td>
<td>0.40</td>
</tr>
<tr>
<td></td>
<td>Method (1934)</td>
<td></td>
</tr>
<tr>
<td>4. Total N (%)</td>
<td>Modified Kjeldahl</td>
<td>0.048</td>
</tr>
<tr>
<td></td>
<td>Method (Jackson, 1967)</td>
<td></td>
</tr>
<tr>
<td>5. Available N (kg/ha)</td>
<td>Alkaline Permanganate</td>
<td>174.4</td>
</tr>
<tr>
<td></td>
<td>Method (Subbiah and Asija, 1956)</td>
<td></td>
</tr>
<tr>
<td>6. Available P (kg/ha)</td>
<td>Olsen's Method</td>
<td>12.2</td>
</tr>
<tr>
<td></td>
<td>(1954)</td>
<td></td>
</tr>
<tr>
<td>7. Available K (kg/ha)</td>
<td>Flame Photometery</td>
<td>178.6</td>
</tr>
</tbody>
</table>

3.3. CLIMATE AND WEATHER CONDITIONS

Lakhaoti has a typical semi-arid and sub-tropical type of climate with extremes of weather conditions. The mean annual
Fig. 1. Weekly meteorological data for the crop season
precipitation is about 630 mm out of which 80% is received from June-September and the rest from October-May. June is the hottest month of the year, whereas July and August are the wettest months. The maximum temperature during the hottest month of June is 43.0°C while the coldest month with the mean temperature of 6.2°C and the minimum 4.0°C in January. The daily minimum and maximum temperature and evaporation rates increase from February onwards up to June, decrease during July to September and drop suddenly reaching the minimum in January. The relative humidity increases from June to September and gradually decreases reaching the minimum during the peak period of January. The mean annual evaporation is 850 mm. The meteorological data for the period of investigation with the weekly means as recorded at the meteorological observatory of the area presented in Appendix I and Fig. 1.

3.4. COPPING HISTORY OF THE EXPERIMENTAL FIELD

The cropping history of the experimental field from 2001-02 to 2004-05 has been presented in Table 2.

<table>
<thead>
<tr>
<th>Year</th>
<th>Season</th>
<th>Crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001-02</td>
<td>Kharif</td>
<td>Sorghum</td>
</tr>
<tr>
<td></td>
<td>Rabi</td>
<td>Barley</td>
</tr>
<tr>
<td>2002-03</td>
<td>Kharif</td>
<td>Sorghum</td>
</tr>
<tr>
<td></td>
<td>Rabi</td>
<td>Wheat</td>
</tr>
<tr>
<td>2003-04</td>
<td>Kharif</td>
<td>Sorghum</td>
</tr>
<tr>
<td></td>
<td>Rabi</td>
<td>Wheat</td>
</tr>
<tr>
<td>-------</td>
<td>---------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>2004-05</td>
<td>Kharif</td>
<td>Sorghum+cowpea</td>
</tr>
<tr>
<td></td>
<td>Rabi</td>
<td>Mustard</td>
</tr>
</tbody>
</table>

3.5. EXPERIMENTAL DETAILS

The experiment was laid out in a factorial randomized block design with three biofertilizers and three levels of nitrogen as main plots during rabi season. Each main plot was further sub-divided into three sub-plots in split plot design which represented the fertility levels applied to the following maize crop.

The details of treatments are given below.

A. N applied (kg/ha) to wheat
   (i) 0  \( N_0 \)
   (ii) 60  \( N_1 \)
   (iii) 120  \( N_2 \)

B. Biofertilizers to wheat
   (i) No biofertilizers  \( B_0 \)
   (ii) *Rhizobacteria* (A combination of *Proteus vulgaris*, *Klebsiella planticola* and *Bacillus subtilis*)  \( B_1 \)
   (iii) *Azotobacter chroococcum*  \( B_2 \)

C. N applied (kg/ha) to maize
   (i) 0  \( F_0 \)
   (ii) 60  \( F_1 \)
   (iii) 120  \( F_2 \)
Fig. 2. Lay out plan of experimental field

EXPERIMENTAL DETAILS

Main plot (rabi)
- $B_0 = \text{No biofertilizer}$
- $B_1 = \text{Rhizobacteria}$
- $B_2 = \text{Azotobacter}$
- $N_0 = \text{No nitrogen (control)}$
- $N_1 = 60 \text{ kg N/ha}$
- $N_2 = 120 \text{ kg N/ha}$

Sub plot (kharif)
- $F_0 = \text{No nitrogen (control)}$
- $F_1 = 60 \text{ kg N/ha}$
- $F_2 = 120 \text{ kg N/ha}$
The sub-plot treatments (F₀, F₁, F₂) for maize crop were super imposed over the main plot treatments (N₀, N₁, N₂ and B₀, B₁, B₂) applied to wheat crop in the previous season as under.

**Main plot treatments to wheat**

\[
\begin{align*}
N₀B₀ & & N₁B₀ & & N₂B₀ \\
N₀B₁ & & N₁B₁ & & N₂B₁ \\
N₀B₂ & & N₁B₂ & & N₂B₂
\end{align*}
\]

**Sub-plot treatments to maize**

\[
\begin{align*}
N₀B₀F₀ & & N₀B₀F₁ & & N₀B₀F₂ \\
N₀B₁F₀ & & N₀B₁F₁ & & N₀B₁F₂ \\
N₀B₂F₀ & & N₀B₂F₁ & & N₀B₂F₂ \\
N₁B₀F₀ & & N₁B₀F₁ & & N₁B₀F₂ \\
N₁B₁F₀ & & N₁B₁F₁ & & N₁B₁F₂ \\
N₁B₂F₀ & & N₁B₂F₁ & & N₁B₂F₂ \\
N₂B₀F₀ & & N₂B₀F₁ & & N₂B₀F₂ \\
N₂B₁F₀ & & N₂B₁F₁ & & N₂B₁F₂ \\
N₂B₂F₀ & & N₂B₂F₁ & & N₂B₂F₂
\end{align*}
\]

Thus, in all three were 27 sub-plot treatments

**Main plot size**

- Gross plot size \(= 11.00 \text{ m} \times 3.25 \text{ m} = 35.75 \text{ m}^2\)
- Net plot size \(= 10.00 \text{ m} \times 2.30 \text{ m} = 23.00 \text{ m}^2\)
Sub-plot size

Gross plot size = 3.00 m x 3.25 m
= 9.75 m²

Net plot size = 2.00 m x 1.95 m
= 3.90 m²

Replication

Total number of main plots = 27
Total number of sub-plots = 81

The plan of layout along with details of treatments has been depicted in Fig. 2.

3.6. FIELD PREPARATION

The experimental field was irrigated prior to sowing in order to facilitate in land preparation. The land was poughed twice by a tractor drawn disc harrow followed by planking.

3.6.1. Cultural operations

The cultural operations carried out in the experimental field on both crops has been given in Table 3.

3.7. DETAILS OF CROPS VARIETIES USED

3.7.1. Wheat (Raj 3765)

Wheat variety Raj 3765 is very promising for late and very late sown area of NWPZ. The optimum sowing time of the variety in NWPZ is second week of November but can be sown till mid December and responds well upto 120 kg N/ha. It is almost 90 cm tall and mature in 110 days under NWPZ situations.
Table-3. Schedule of cultural operations carried out in the experimental field

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Operations</th>
<th>2005-06</th>
<th>2006-07</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Wheat</td>
<td>Maize</td>
</tr>
<tr>
<td>A.</td>
<td>Field preparation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i)</td>
<td>Ploughing</td>
<td>12.12.05</td>
<td>24.06.06</td>
</tr>
<tr>
<td>(ii)</td>
<td>Harrowing (twice)</td>
<td>13.12.05</td>
<td>25.06.06</td>
</tr>
<tr>
<td>(iii)</td>
<td>Ridge making</td>
<td>-</td>
<td>27.06.06</td>
</tr>
<tr>
<td>B.</td>
<td>Layout and sowing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i)</td>
<td>Layout</td>
<td>15.12.05</td>
<td>28.06.06</td>
</tr>
<tr>
<td>(ii)</td>
<td>Sowing</td>
<td>17.12.05</td>
<td>29.06.06</td>
</tr>
<tr>
<td>(iii)</td>
<td>Seed inoculation</td>
<td>17.12.05</td>
<td>-</td>
</tr>
<tr>
<td>C.</td>
<td>Herbicide application</td>
<td>-</td>
<td>17.06.06</td>
</tr>
<tr>
<td>D.</td>
<td>Fertilizer application</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i)</td>
<td>Basal application</td>
<td>17.12.05</td>
<td>29.06.06</td>
</tr>
<tr>
<td>(ii)</td>
<td>Top dressing</td>
<td>13.01.06</td>
<td>27.07.06</td>
</tr>
<tr>
<td>E.</td>
<td>Irrigation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i)</td>
<td>Pre-sowing irrigation</td>
<td>04.12.05</td>
<td>-</td>
</tr>
<tr>
<td>(ii)</td>
<td>1st irrigation</td>
<td>09.01.06</td>
<td>25.07.06</td>
</tr>
<tr>
<td>(iii)</td>
<td>IInd irrigation</td>
<td>08.02.06</td>
<td>07.08.06</td>
</tr>
<tr>
<td>(iv)</td>
<td>IIIrd irrigation</td>
<td>26.02.06</td>
<td>-</td>
</tr>
<tr>
<td>(v)</td>
<td>IVth irrigation</td>
<td>22.03.06</td>
<td>-</td>
</tr>
<tr>
<td>(vi)</td>
<td>Vth irrigation</td>
<td>06.04.06</td>
<td>-</td>
</tr>
<tr>
<td>F.</td>
<td>Weeding</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i)</td>
<td>1st hand weeding</td>
<td>19.01.06</td>
<td>17.07.06</td>
</tr>
<tr>
<td>(ii)</td>
<td>IInd hand weeding</td>
<td>14.02.06</td>
<td>14.08.06</td>
</tr>
<tr>
<td>(iii)</td>
<td>IIIrd hand weeding</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>G.</td>
<td>Pest control</td>
<td>-</td>
<td>20.08.06</td>
</tr>
<tr>
<td>H.</td>
<td>Harvesting</td>
<td>30.04.06</td>
<td>09.10.06</td>
</tr>
<tr>
<td>I.</td>
<td>Threshing</td>
<td>12.05.06</td>
<td>10.11.06</td>
</tr>
</tbody>
</table>
Thus variety has erect growth habit and light green non-waxy leaves and produces dusty white ear colour at the time of manurity. The variety can yield 35-40 q/ha with amber semi-hard grain, has 40 g thousand gram weight and is considered good for chapati making. The variety is resistant to leaf and stripe rusts and tolerant to Karnal bunt.

3.7.2. Maize (Daccan 103)

A hybrid which takes about 105-110 days to mature, has wide adaptability, thick stem with broad dark-green leaves. Plants are usually 1.5 to 2.0 meters tall, stem tightly covered with leaves. The variety is resistant to lodging, downy mildew and leaf blight. It has a yield potential of 45-55 q/ha with bold grain, yellow in colour and semi-dent type.

3.8. SEED AND SOWING

Wheat (Raj 3765) was sown in the rows spaced at 23 cm apart by pora method with a seed rate of 140 kg/ha.

Maize (Daccan 103) was sown in furrows with a seed rate of 15 kg/ha spaced 65 cm apart and two seeds per hole were sown at 20 cm distance. Plant population of 77,000/ha was maintained by gap filling, if necessary at 10 DAS.

3.8.1. Seed inoculation

Both the biofertilizers were collected from the Division of Microbiology, Indian Agricultural Research Institute, New Delhi. A thick paste of each inoculant was prepared with jaggery. The seeds of wheat were well smeared with inoculant.
The treated seeds were then spread on a paper in shade for drying and setting of inoculant thoroughly with seeds.

3.9. SOURCE OF FERTILIZERS

N : Prilled urea (46% N)

P$_2$O$_5$ : Single superphosphate (16% P$_2$O$_5$)

K$_2$O : Murate of potash (60% K$_2$O)

3.10. FERTILIZER APPLICATION

3.10.1. Wheat

Wheat received a uniform dose of 60-40 kg/ha of P$_2$O$_5$-K$_2$O at the time of sowing, which was broadcast and thoroughly mixed into the soil. Nitrogen was applied in different plots as per the treatments. Half dose of N was applied at sowing as basal and remaining half was top dressed at the time of 1st irrigation.

3.10.2. Maize

Maize received variable amounts of N in different plots as per the treatments. Half dose of N was applied at time of sowing in furrows and the remaining half was side dressed at 30 days after sowing. A uniform dose of 60-40 kg/ha of P$_2$O$_5$-K$_2$O was applied uniformly at planting, respectively.

3.11. WEEDING AND INTERCULTURE

Manual intercultivation was done with the help of hand plough and Khurpi to check the weed growth in wheat as well as in maize. Weed free conditions helped in soil aeration, facilitated root growth and make the soil receptive to moisture.
3.12. IRRIGATION

Wheat crop was entirely supported by irrigation during both the years. In case of maize, irrigation was provided to supplement the rainfall. Detail schedule of irrigation indicating time and number of irrigations for each crop is given in Table 3.

3.13. PEST CONTROL

Wheat crop did not need any insect-pest control measures during both the years. Maize crop during both the years was protected against infestation of top borer, which was controlled by the application of 3% carbofuran granules at the rate of 15 kg/ha.

3.14. HARVESTING AND THRESHING

The net plots after removing the border rows were harvested manually and left to dry for 4-5 days in the field. Wheat crop was threshed mechanically after sun drying. Maize crop was also harvested manually and threshed mechanically after thoroughly sun drying the cobs.

3.15. BIOMETRICAL OBSERVATIONS

Observations on growth, yield attributes and yield were recorded.
WHEAT

3.15.1. Pre-harvest studies

3.15.1.1. Plant population

The plant population of wheat per metre row length was counted from three randomly selected spots in each net plot at 40 DAS.

3.15.1.2. Plant height

Five plants from the net plot were randomly selected and tagged for all the periodic height observations and it was recorded in cm from the ground level to the base of flag leaf at 40, 80 and 120 DAS.

3.15.1.3. Dry matter accumulation

The second row from border on either side of plot was used for collecting samples. Samples were taken at 40, 80 and 120 DAS and at harvest. The samples were sun dried first and then in an oven at 65°C before recording the constant weight. The dry weight was expressed as g/plant.

3.15.1.4. Leaf area index (LAI)

LAI was calculated at 40, 80 and 120 days after sowing the crop. The leaves were stripped off from their base from the collected samples for dry matter accumulation. Total area of all the leaves was determined with the help of a leaf area meter (Licor, USA). LAI was expressed as the ratio of leaf area to the land area occupied by the plant.
3.15.1.5. **Number of tillers/plant**

Five plants from the net plot were subjected to random selection and tagged for all the periodic observations. The number of tillers/plant were recorded at 40, 80 and 120 DAS.

3.15.2. **Post-harvest studies**

3.15.2.1. **Length of spike**

The length of 10 spikes (cm) collected randomly from the net plot was recorded from neck to the tip of the ear and mean values were computed.

3.15.2.2. **Number of spikelets/spike**

Total number of spikelets/spike were counted from ten randomly selected spikes from the net plot and expressed as the number of spikelets/spike.

3.15.2.3. **Biological yield**

Total biomass of each net plot was sun dried for 3 to 4 days after harvesting and then weight was recorded with spring balance (kg/plot). Finally total biological yield was expressed as q/ha.

3.15.2.4. **Grain yield**

Total biomass of each net plot was weighed and threshed after harvesting. The grain was cleaned and sun dried for 3 to 4 days and weight was recorded. Final yield was expressed in q/ha.
3.15.2.5. Straw yield

The weight of straw was computed by subtracting the weight of drain from total dry matter yield of each net plot. Final yield was expressed in q/ha.

3.15.2.6. Harvest index (%)

This was calculated by using the following formula as suggested by Singh and Stoskaif (1971).

\[
\text{Harvest index} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100 = \frac{\text{Grain yield}}{\text{Grain + straw yield}} \times 100
\]

MAIZE

3.15.3. Pre-harvest studies

3.15.3.1. Plant population

The plant population count was recorded in each net plot prior to harvest and values reported as '000 plant/ha.

3.15.3.2. Plant height

Five plants from the net plot were randomly selected, tagged and height was recorded at 30, 60 DAS and at harvest during both the years. The plant height was measured from the ground level to the base of the fully opened leaf in pre-tasselling and upto the base of tassel at post-tasselling stage.

3.15.3.3. Leaf area index (LAI)

There plants were randomly removed from the border rows. The leaves were stripped off from their base and area of all the leaves was recorded with the help of an area meter (Licor, USA). Leaf area was recorded at 30, 60 and 90 DAS.
3.15.4. Post-harvest studies

3.15.4.1. Cob length

Five cobs were randomly selected from each plot during harvest and their length from base to tip of the cobs were recorded in cm.

3.15.4.2. Cob girth

The girth of five cobs was measured at the middle portion of the cob and the mean value was recorded.

3.15.4.3. Number of grains/cob

Five cobs sampled at the time of harvest were considered for counting the number of grain rows/cob and number of grains/grain row. The product of these two parameters represented the number of grains per cob.

3.15.4.4. Test weight

After thorough sun drying the grains, 1,000 grains/plot were counted and their weight was recorded.

3.15.4.5. Grain yield

Fresh weight of the cobs from the net plot of maize were recorded. Thereafter, all the cobs were dried in the sun and threshed by a mechanical thresher. The grain yields were adjusted to 15% moisture content. For this, five cobs from each net plot were subjected at random for determining their shelling percentage and moisture content.

\[ A = \text{Shelling (\%)} = \frac{\text{Weight of grain}}{\text{Weight of cobs}} \times 100 \]
3.15.4.6. **Stover yield**

The maize stalks were cut from ground level from the net plot and weighed after sun drying. Final yield was expressed in q/ha.

3.16. **CHEMICAL STUDIES**

3.16.1. **Nitrogen content and uptake**

Plan samples taken for dry matter accumulation at different stages of crop growth were used for chemical analysis. Nitrogen content in grain and straw of both the crops were determined by Kjeldahl method (Subbiah and Asija, 1956). Nitrogen uptake was worked out by multiplying the nitrogen % of grain and straw with the corresponding yield/ha and expressed as N kg/ha. The nitrogen uptake by grain and straw was added to get the total nitrogen uptake by wheat and maize crop.

3.16.2. **N use efficiency (NUE)**

Nitrogen use efficiency was determined by the following expressions.

\[
\text{Nitrogen use efficiency (NUE)} = \frac{Y_t - Y_0}{A_t} \text{ kg grain/kg nitrogen applied}
\]

Where, \(Y_t\) = Yield under treatment (kg/ha)

\(Y_0\) = Yield under control (kg/ha)

\(A_t\) = Units of nitrogen applied in the test treatment (kg/ha)
3.16.3. Physiological efficiency (PE)

Physiological efficiency (PE) = \( \frac{Y_t - Y_0}{U_t - U_0} \) kg grain / kg N uptake

Where, \( Y_t \) = Yield under treatment (kg/ha)
\( Y_0 \) = Yield under control (kg/ha)
\( U_t \) = Uptake of nitrogen in test treatment (kg/ha)
\( U_0 \) = Uptake of nitrogen in control (kg/ha)

3.16.4. Apparent N recovery

Apparent N recovery (%) = \( \frac{N_t - N_0}{N_a} \)

Where, \( N_t \) = Amount of nitrogen taken up from treatment plot (kg/ha)
\( N_0 \) = Amount of nitrogen taken from control plot (kg/ha)
\( N_a \) = Amount of nitrogen added (kg/ha)

3.16.5. Nitrogen harvest index (%)

Nitrogen harvest index (%) (Austin et al., 1977) = \( \frac{N_s}{N_t} \) x 100

\[ = \frac{\text{Nitrogen uptake by grain}}{\text{Nitrogen uptake (grain + straw)}} \times 100 \]

3.16.6. Crude protein content (%) and yield (kg/ha)

Crude protein percentage in grain was obtained by multiplying the percentage of nitrogen with 5.70 (AOAC, 1960) and finally crude protein yield was calculated by the following formula.
Crude protein yield (kg/ha) = Crude protein (%) x Grain yield (kg/ha)

3.17. SOIL STUDIES
3.17.1. Initial soil sampling

Soil samples were taken from 5 locations in each replication using an auger to a depth of 0-15 cm. Collected soil samples from all replications were air dried and mixed thoroughly to make one composite sample and half of this was mixed again thoroughly and it was again divided in two parts. The final prepared soil sample was used for the determination of initial fertility status of experimental field in the laboratory.

Similarly, plot wise soil samples were also collected after harvest of the crop in every season. These samples were analysed for their available nitrogen, phosphorus and organic carbon content. Available nitrogen content was determined by alkaline permanganate method (Jackson, 1967) and expressed as kg N/ha. The organic carbon was determined by Walkley and Black method (1934).

3.17.2. Bulk density (g/cc)

Bulk density of the soil was determined with the help of soil core sampler using the following formula:

\[
\text{Bulk density} = \frac{\text{Weight of oven dry soil core}}{\text{Volume of core sampler}}
\]
Soil samples were collected after harvest of the crop in each season. Bulk density was expressed as gram per cubic centimetre (g/cc).

3.18. ECONOMIC ANALYSIS

3.18.1. Cost of cultivation (Rs/ha)

Cost of cultivation for wheat and maize was worked out separately as well as wheat-maize cropping sequence. Requirements of labour and mechanical power for different operations, such as land preparation, sowing, weeding, fertilizer application, harvesting, threshing etc. were calculated as per rates applicable during the period of experimentation (Appendix-II-A & II-B).

3.18.2. Gross returns

Gross returns (yield x price) was worked out on the basis of prevailing market prices.

3.18.3. Net returns

Net return was calculated by following formula:

\[
\text{Net returns (Rs/ha)} = \text{Gross returns (Rs/ha)} - \text{cost of cultivation (Rs/ha)}
\]

3.18.4. Benefit : cost ratio

Benefit : cost ratio was calculated by dividing net returns with the cost of cultivation of pertinent treatment.

3.19. STATISTICAL ANALYSIS

All the data were analysed by applying the technique of analysis of variance as described by Cochran and Cox (1957).
The significance was tested by 'F' test and critical difference (CD, P = 0.05) was calculated to compare the differences of treatment means. Interaction effects have been discussed wherever found significant. Graphical presentation is also given wherever necessary.