MATERIALS AND METHODS
The present investigation "Effect of Integrated Plant Nutrient Management (INM) on soils nutrient uptake and yield of mustard" was conducted during cropping season of 2003-2004. The materials used, experimental procedure followed and techniques adopted during the course of experimentation have been described in this chapter under following heads.

3.1 Preliminary information

3.1.1 Experimental site

The experiment was conducted at the Instructional farm of Tilak Dhari Posty Graduate College, Jaunpur (U.P.) India during the Rabi seasons of 2003-2004. The research farm is located 02 km away from Jaunpur district head quarter on Jaunpur – Zafarabad road.

3.1.2 Climate

The climate of the area is semi arid with hot summer and cold winters. This region receives an average annual rainfall of about 1280 mm. The rainfall is erratically distributed. The major part of rain is received from mid July to September. Data on weather during crop season have been presented in Appendix -1.

3.1.3 Characteristics of experimental soil

In order to determine the physico-chemical properties of the soil and its fertility status, soil samples were collected randomly from different places of
the field with the help of soil auger to a depth of 0-15 cm before applying the treatments. The soil sample taken from each spots were mixed together and a composite sample was prepared and analyzed for different properties of soil. The physico-chemical properties of soil of the experimental field are given in Table 3.1.

Table 3.1 Physico-chemical properties of experimental soil:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Soil properties</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Water Holding Capacity (%)</td>
<td>20.55</td>
</tr>
<tr>
<td>2.</td>
<td>Bulk Density (MgM⁻³)</td>
<td>1.62</td>
</tr>
<tr>
<td>3.</td>
<td>Electrical Conductivity (dSm⁻¹ 1 : 2.5)</td>
<td>0.31</td>
</tr>
<tr>
<td>4.</td>
<td>pH (Soil 1 : 2.5)</td>
<td>7.90</td>
</tr>
<tr>
<td>5.</td>
<td>Organic Carbon (%)</td>
<td>0.33</td>
</tr>
<tr>
<td>6.</td>
<td>Available Nitrogen (kg ha⁻¹)</td>
<td>121.00</td>
</tr>
<tr>
<td>7.</td>
<td>Total Nitrogen (kg ha⁻¹)</td>
<td>520.00</td>
</tr>
<tr>
<td>8.</td>
<td>Available P₂O₅ (kg ha⁻¹)</td>
<td>18.75</td>
</tr>
<tr>
<td>9.</td>
<td>Total P₂O₅ (kg ha⁻¹)</td>
<td>303.00</td>
</tr>
<tr>
<td>10.</td>
<td>Available K₂O (kg ha⁻¹)</td>
<td>228.00</td>
</tr>
<tr>
<td>11.</td>
<td>Total K₂O (kg ha⁻¹)</td>
<td>913.00</td>
</tr>
<tr>
<td>12.</td>
<td>Available Sulphur (kg ha⁻¹)</td>
<td>6.18</td>
</tr>
<tr>
<td>13.</td>
<td>Total Sulphur (kg ha⁻¹)</td>
<td>18.75</td>
</tr>
<tr>
<td>14.</td>
<td>Available Boron (ppm)</td>
<td>4.48</td>
</tr>
<tr>
<td>15.</td>
<td>Total Boron (ppm)</td>
<td>15.90</td>
</tr>
</tbody>
</table>
3.2 Lay out plan

The experiment was laid out in a Randomized Block Design (RBD) with three replications (fig. 3.1). The gross plot size was kept 4m x 5m.

3.2.1 Details of the experiment

Table 3.2

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Treatment details</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₀</td>
<td>Control</td>
</tr>
<tr>
<td>T₁</td>
<td>100% NPK (100 : 60 : 40)</td>
</tr>
<tr>
<td>T₂</td>
<td>50% NPK (50 : 30 : 20)</td>
</tr>
<tr>
<td>T₃</td>
<td>100% NPK + 10 t FYM ha⁻¹</td>
</tr>
<tr>
<td>T₄</td>
<td>50% NPK + 10 t FYM ha⁻¹</td>
</tr>
<tr>
<td>T₅</td>
<td>100% NPK + 25 kg S ha⁻¹</td>
</tr>
<tr>
<td>T₆</td>
<td>50% NPK + 25 kg S ha⁻¹</td>
</tr>
<tr>
<td>T₇</td>
<td>100% NPK + 1 kg B ha⁻¹</td>
</tr>
<tr>
<td>T₈</td>
<td>50% NPK + 1 kg B ha⁻¹</td>
</tr>
<tr>
<td>T₉</td>
<td>100% NPK + 10 t FYM ha⁻¹ + 25 kg S ha⁻¹</td>
</tr>
<tr>
<td>T₁₀</td>
<td>50% NPK + 10 t FYM ha⁻¹ + 25 kg S ha⁻¹</td>
</tr>
<tr>
<td>T₁₁</td>
<td>100% NPK + 10 t FYM ha⁻¹ + 1 kg B ha⁻¹</td>
</tr>
<tr>
<td>T₁₂</td>
<td>50% NPK + 10 t FYM ha⁻¹ + 1 kg B ha⁻¹</td>
</tr>
</tbody>
</table>

(i) Number of treatments 13
(ii) Replications 4
(iii) Design RBD
(iv) Plot size 5m x 5m
(v) Total number of plots 52
### Table 3.3 Details of operations during crop growth

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Operation</th>
<th>Date of operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Preparation of field</td>
<td>29.10.2003</td>
</tr>
<tr>
<td>2.</td>
<td>Preparation of layout</td>
<td>30.10.2003</td>
</tr>
<tr>
<td>3.</td>
<td>Incorporation of FYM</td>
<td>01.11.2003</td>
</tr>
<tr>
<td>4.</td>
<td>Fertilizer application</td>
<td>17.11.2003</td>
</tr>
<tr>
<td>5.</td>
<td>Sowing of seed</td>
<td>17.11.2003</td>
</tr>
<tr>
<td>10.</td>
<td>Weeding II</td>
<td>Nil</td>
</tr>
<tr>
<td>12.</td>
<td>Plant protection</td>
<td>18.01.2004</td>
</tr>
<tr>
<td>13.</td>
<td>Irrigation II</td>
<td>22.01.2004</td>
</tr>
<tr>
<td>14.</td>
<td>Second top dressing of urea</td>
<td>26.01.2004</td>
</tr>
<tr>
<td>15.</td>
<td>Harvesting</td>
<td>25.03.2004</td>
</tr>
</tbody>
</table>

### 3.2.2 Fertilizer doses

(a) 100% NPK – 100 kg N, 60 kg P$_2$O$_5$ and 40 kg K$_2$O ha$^{-1}$

(b) 50% NPK – 50 kg N, 30 kg P$_2$O$_5$ and 20 kg K$_2$O ha$^{-1}$
(c) Farm yeard manure @ 10 t ha$^{-1}$
(d) Sulphur @ 25 kg ha$^{-1}$
(e) Boron @ 1.0 kg ha$^{-1}$

3.2.3 Experimental layout

An area of 1896 square meter was selected at the student instructional farm of T.D.P.G. College, Jaunpur and divided in 52 plots, each of 5m x 4 m. The plot was separated from each other by providing 50 cm size bond all round the each plot. The layout plan of the experiment is shown in figure 3.1.

3.3 Agronomical practices

3.3.1 Preparation of field

The experimental field was properly leveled followed by preparatory irrigation afterward at optimum tilth, the field was ploughed and layout was done as per programme.

3.3.2 Application of FYM

It was applied and mixed before sowing @ 10 t ha$^{-1}$ as per treatments in the field.

3.3.3 Application of nitrogen, phosphorus and potassium

Full dose of phosphorus, potassium and half dose of nitrogen was applied as basal through urea, DAP and muriate of potash while remaining half amount of nitrogen was applied at flowering stage.
Fig.: Layout plan of experimental field

- Main Irrigation Channel
- Sub-Irrigation Channel
- Field Border
- Extra Plot

Dimensions:
- Width: 39.5 m
- Length: 48 m
3.3.4 Application of sulphur

The sulphur was applied to sulphur powder in the row of mustard at the time of sowing.

3.3.5 Application of boron

The required amount of boron was given at the time of sowing in the form of borax.

3.3.6 Sowing of mustard seed

Variety Shekhar was sown @ 6 kg ha\(^{-1}\) in furrow opened at a distance of 30 cm with help of Kudal at the depth of 3 cm in rows.

3.3.7 Thinning and inter-culture operation

Thinning was done in two phase in the first phase of thinning, the dense emerging seedling were thinned at 20 DAS, second phase of thinning was completed by maintaining plant to plant distance 20 cm at 30 DAS. Weeding was done as and when required to remove unwanted plants. Care was taken to maintain the moisture in soil for which irrigation was provided as and when needed.

3.3.8 Spraying of insecticide and pesticides

To check the damage by mustard saw fly thiodon spraying was done @ 1.25 litre ha\(^{-1}\). Dimecron 35 EC @ 250 ml ha\(^{-1}\) was sprayed as precautionary measures to check the infestation of aphids.

3.3.9 Irrigation

Two irrigations were given to mustard crop. First irrigation was applied one month after sowing and second at the end of flowering.
3.3.10 Harvesting

The crop of each plot was harvested separately on its complete maturity at about 13% grain moisture.

3.3.11 Threshing, winnowing and bagging

After harvesting, the produce was kept for sun drying in the field for a week and threshed separately with the help of sticks by labours.

3.3.12 Collection of plant samples and soil samples

Plant samples were collected at 30, 90 DAS and at harvest stage of crop, these samples were oven dried, ground and used for analysis of total N, P, K, S and B content. Soil samples were collected plot wise at the time of harvesting of the crop for the determination of various soil properties and nutrient content.

3.4 Observations recorded

(A) Physiological status:

3.4.1 Chlorophyll content

The chlorophyll content of fresh leaves was estimated following the method of Arnon (1949) and expressed as mg g\(^{-1}\) fresh weight.

3.4.2 Leaf area Index

During measurement of leaf length the width of leaf was also recorded simultaneously leaf area of one leaf was calculated by multiplying length, width and factor (0.75) mutually. The leaf area of one leaf was multiplied by total number of leaves present in a unit area to obtain total leaf area and was divided by unit ground area to get leaf area index.
The leaf area index was calculated according to the formula given by Watson (1947) as mentioned below:

\[
\text{LAI} = \frac{\text{Leaf area}}{\text{Ground Area}}
\]

(B) Agronomical studies

3.4.3 Primary and secondary branches plant\(^{-1}\)

Primary and secondary branches of five random plants under each treatment were counted at 60 and 90 days after sowing. Total number of branches was counted and mean values have been calculated.

3.4.4 Plant height

Five plants selected randomly from each plot were tagged. The height was measured in cm with the help of meter scale from the base of the plant to the top of the plant and mean values were computed.

3.4.5 Number of siliqua plant\(^{-1}\)

The siliqua presented in five randomly selected plants were separated and counted and average of it was reported as number siliqua per plant.

3.4.6 Number of seed siliqua\(^{-1}\)

Randomly selected siliqua taken from respective plant, were threshed, and seeds were counted and average number has been reported as number of seeds per siliqua.

3.4.7 Test weight

Samples of seed were taken from each plot and 1000 seeds were counted from each treatment. The counted seeds were weighed and recorded as test weight.
3.4.8 Seed yield

The individual plot was harvested and produce was air dried and crop was threshed and produce was cleaned. The final weight was recorded in kg per plot converted into quintal per hectare.

3.4.9 Stover yield

Stover yield was computed by deducting the seed yield from total biological yield recorded per plot and expressed in quintal per hectare.

3.4.10 Harvest index

The harvest index was computed on the basis of seed yield and total biomass production and presented in term of per cent. The harvest index was calculated by following formula:

\[
\text{Harvest index} = \frac{\text{SY}}{\text{SY} + \text{Sy}} \times 100
\]

Where,

SY = Seed yield (q ha\(^{-1}\))

Sy = Stover yield (q ha\(^{-1}\))

(C) Quality parameters

3.4.11 Oil content

Seed samples were kept in the oven at 70\(^{0}\)C for removal of the moisture. Thereafter, the seeds were grinding in a pestle mortar for extraction of oil. The conventional soxhlat method was used for estimation of oil (A.O.A.C. 1970).
3.4.12 Protein content

Seeds were analyzed for nitrogen content and protein content was computed by multiplying N content with a constant factor of 6.25 and expressed in per cent (Jackson, 1973).

3.5 Chemical studies

(a) Plant studies

3.5.1 Nitrogen content

Nitrogen content of mustard at different stages was determined by modified Micro-Kjeldahl's method (Jackson, 1973). At harvest, the content was determined in seed and stover, separately.

3.5.2 Phosphorus content

Phosphorus content of mustard at different growth stages was determined by Vandomolybadate phosphoric yellow colour method as described by Jackson (1973).

3.5.3 Potassium content

Potassium content of the plant samples at different growth stages was determined by flame photometer Jackson (1973).

3.5.4 Sulphur content

For determination of sulphur, powdered plant material was digested with diacid mixture having nitric acid and perchloric acid in 4 : 1 ratio. Sulphur in the digested material was determined turbidimetric method as described by Chesnin and Yien (1951).
3.5.5 Boron content

Boron was determined to Azomethine H method (Jhon, 1975). The method employed azomethine H as the reagent to form a stable coloured complex of \( \text{H}_3\text{PO}_4 \). The colour is measured by spectrophotometer

(b) Nutrient uptake

At harvest nitrogen, phosphorus, potassium, sulphur and zinc contents in seed and stover was determined separately and multiplied with their respective yield values under each treatment to obtain removal of nutrients by crop.

(c) Soil studies

3.5.6 Water holding capacity

The water holding capacity was determined by the circular brass boxes method (Chopra and Kanwar, 1980).

3.5.7 Bulk density

Bulk density (BD) was measured by the following formula:

\[
\text{Bulk density} = \frac{\text{Weight oven dried soil}}{\text{Field volume of sample}}
\]

3.5.8 Electrical conductivity

Electrical conductivity was determined by conductivity meter using 1 : 2.5 soil suspension as stated by Jackson (1973).
3.5.9 Soil pH

It was measured with the help of pH meter using glass electrode in 1:2.5 soil water suspension as stated by Jackson (1973).

3.5.10 Organic carbon

Organic carbon was estimated by Walkley and Black’s (1939) rapid titration method as advocated by Jackson (1973).

3.5.11 Available nitrogen

Available nitrogen content in soil samples was estimated by alkaline permanganate method as described by Subbiah and Asija (1956).

3.5.12 Total nitrogen

The total nitrogen content in soil was determined by micro kjeldahl flasks method Jackson (1973).

3.5.13 Available phosphorus

Available phosphorus was extracted by 0.5 MNaHCO₃ (pH 8.5) as per procedure of Olson’s et al. (1954) determined colorimetrically by molybdophosphoric blue colour method.

3.5.14 Total phosphorus

Total phosphorus in soil was analyzed by digestion method consisting of extraction of soil with HClO₄ with subsequent characteristics colour by ammonium vandate. The intensity of which was then compared and measured with the help of standard phosphate solution using, Spectronic -20 at 440 mp, wave length Jackson (1973) and content of total P of soil was computed as below:
Total phosphorus (kg ha\(^{-1}\)) Micrograms of P\(_2\)O\(_5\) present in extract of 1 g soil x 2.

3.5.15 Available potassium

Available potassium in soil was determined by Flame photometerically by using neutral normal ammonium acetate solution as described by Jackson (1973).

3.5.16 Total potassium

Total potassium was determined by a wet digestion of soil with hydrofluoric acid and perchloric acids as described by Jackson (1973).

3.5.17 Available sulphur

Available sulphur in soil was determined turbidimetrically as barium sulphate by the method of Chesnin and Yien (1951).

3.5.18 Total sulphur

Total sulphur in soil was determined by precipitation as barium sulphate method as described by Chopra and Kanwar (1991)

3.5.19 Boron

Boron was determined to Azomethine H method (John, 1975). The method employed azomethine H as the reagent to form a stable coloured complex of H\(_3\)PO\(_4\). The colour is measured spectrophotometrically.

3.6 Economics

Cost of cultivation on hectare basis was worked out at prevailing market rates. Gross income was calculated by adding the revenues obtained from seed and stover yield. Net income in rupees was worked out by subtracting the total cost of cultivation from gross income. Rate of the commodities are mentioned in Appendix-1.