CHAPTER III

METHODS AND MATERIALS

The experiments were conducted under field conditions at the research farm of the Institute of Advanced Studies, Meerut University, Meerut, during the rabi seasons of 1971-72 and 1972-73. The details of materials used and methods followed in conducting the experiments are described in this chapter.

1. CLIMATE

Meerut, situated at 29°01' N latitude, 77°43' E longitude and 222 m above the mean sea level, belongs to a typical semi-arid and subtropical climate group with an average annual rainfall of about 780 mm, more than three-fourth received during the months of July, August and September. Winters are cool with lowest temperature in January ranging between 20.6°C and 7.9°C and with extremes of 27.2°C to 17°C. The temperature increases from February onwards to June and decreases thereafter. June is the hottest month with an average minimum and maximum temperatures of 19.4°C and 45.0°C respectively. The highest wind velocity of 8-9 km per hour is experienced in the month of June while the minimum of 4.9 km per hour in the month of January. The wind storms are generally associated with the late monsoon rains, winter rains and hot summers.
Fig. 1 MEAN WEEKLY TEMPERATURES AND RELATIVE HUMIDITY DURING THE GROWING SEASONS
Fig. 2 MEAN WEEKLY EVAPORATION, WIND VELOCITY AND RAINFALL DURING THE GROWING SEASONS
The highest relative humidity reached in the month of September, gradually decreases towards minimum in the month of June. The mean evaporation rate increases from minimum of 2-3 mm per day in January to maximum of 12-15 mm per day in May and June. The weekly climatic data recorded on various weather parameters during the course of the experimentation are presented in Fig.1 and 2.

2. SOILS

The farm soils are well drained sandy loam. The composite samples collected from a soil depth of 0-30 cm were analysed for physico-chemical constants. Some of the physical constants viz., field capacity, wilting point, bulk density and available water were analysed depth-wise. The values obtained are given in Table 1.

Table 1. Physico-chemical properties of the soils.

(a) Mechanical composition:

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Composition (%)</th>
<th>Methods used</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1971-72</td>
<td>1972-73</td>
</tr>
<tr>
<td>Coarse sand</td>
<td>33.0</td>
<td>33.0</td>
</tr>
<tr>
<td>Fine sand</td>
<td>16.5</td>
<td>16.5</td>
</tr>
<tr>
<td>Silt</td>
<td>28.0</td>
<td>28.0</td>
</tr>
<tr>
<td>Clay</td>
<td>20.0</td>
<td>20.0</td>
</tr>
</tbody>
</table>
Table 1 (Contd.)

(b) Chemical composition:

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Composition (%)</th>
<th>Methods used</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1971-72</td>
<td>1972-73</td>
</tr>
<tr>
<td>Available nitrogen (kg/ha)</td>
<td>72.5</td>
<td>76.5</td>
</tr>
<tr>
<td>Available P₂O₅ (kg/ha)</td>
<td>45.8</td>
<td>48.6</td>
</tr>
<tr>
<td>Available K₂O (kg/ha)</td>
<td>88.2</td>
<td>91.5</td>
</tr>
<tr>
<td>Organic carbon (%)</td>
<td>1.05</td>
<td>1.12</td>
</tr>
<tr>
<td>Soil pH</td>
<td>7.8</td>
<td>7.8</td>
</tr>
<tr>
<td>E.C. (millimhos/cm)</td>
<td>0.82</td>
<td>0.82</td>
</tr>
</tbody>
</table>

(c) Physical constants:

<table>
<thead>
<tr>
<th>Particulars</th>
<th>0-20</th>
<th>20-24</th>
<th>40-60</th>
<th>Methods used</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field capacity (%)</td>
<td>19.8</td>
<td>20.6</td>
<td>20.8</td>
<td>Field method (Coleman, 1944).</td>
</tr>
<tr>
<td>Wilting point(%)</td>
<td>6.6</td>
<td>7.4</td>
<td>7.6</td>
<td>Sunflower method, (Piper, 1950).</td>
</tr>
<tr>
<td>Bulk density (g/cm³)</td>
<td>1.45</td>
<td>1.51</td>
<td>1.52</td>
<td>Core sampler (Piper, 1950).</td>
</tr>
<tr>
<td>Available water (%)</td>
<td>13.20</td>
<td>13.20</td>
<td>13.20</td>
<td>(Field capacity - Wilting point).</td>
</tr>
</tbody>
</table>
3. PRESEWING OPERATIONS

Maize/sorghum-wheat were the common crops and rotations followed in the fields before taking the experimental crops. After harvesting maize/sorghum one descing was done in the early October followed by two light ploughings. Uniform 10 cm presowing irrigation was applied 3–4 days before preparation of the field. One descing and one cultivator ploughing were applied followed by final planking. Soil samples for chemical and mechanical analysis were collected before fertilizer application.

4. TREATMENTS AND FIELD LAYOUT

The experiments were conducted following a split-plot design with the varieties randomised in main plots and fertilizers and mulches in sub-plots. The details of the treatments of varieties, nitrogen and mulches are reported as under and the layout plan shown in Fig. 3.

A. Main plot treatments:

1. Varieties
   a. Kalyan Sona (HD 1593)
   b. Sonalika (HD 1553)
   c. Heera (HD 1941)
   d. Moti (HD 1949)

Notations

V
V1
V2
V3
V4
Fig. 3 LAY-OUT PLAN
DESIGN - SINGLE SPLIT PLOT
REPLICATION 3

GROSS PLOT SIZE 5m X 5m
NET PLOT SIZE 3m X 2.5m
PLOT BORDERS 0.5 m
BLOCK BORDERS 0.5 m
WIDTH OF BUFFER STRIP 1.0 m
TOTAL NO. OF TREATMENT 32

VARIETIES
V1 - KALYAN SONA (HD 1593)
V2 - SONALIKA (HD 1553)
V3 - HEERA (HD 1944)
V4 - MOTI (HD 1945)

LEVELS OF NITROGEN
N1 - 60 Kg N / ha
N2 - 150 Kg N / ha

MULCHES
M0 - CONTROL (NO MULCH)
M1 - SAND MULCH 1/25 cm THICK
M2 - SAW DUST (1/25 cm THICK)
M3 - POLYETHYLENE (20 cm SAUCE SHEETS)
B. Sub-plot treatments

(a) Nitrogen levels
   1. 60 kg/ha (medium)  
   2. 150 kg/ha (high)  

(b) Soil mulches
   1. Control (no mulch)
   2. Sand mulch (1.25 cm thick layer of fine sand spread all over the field)
   3. Sawdust mulch (1.25 cm thick layer of sawdust spread all over the field)
   4. Polyethylene mulch (200 gauge plastic sheet spread all over the field)

Notations
N
M
M1
M2
M3
Me

5. APPLICATION OF FERTILIZERS

Half of the total nitrogen and total of $P_2O_5$ and $K_2O$ were applied through urea (46% N), Diammonium phosphate (46% $P_2O_5 + 18\%$ N) and muriate of potash (60% $K_2O$) respectively at 5 cm away on one side of the seed and 6 cm below the seed. The remaining nitrogen was sprayed as 3% urea solution in 5 equal instalments starting from one month after sowing till ear emergence.

6. PLANT MATERIAL

1. Kalyan Sona (HD 1593)

A double dwarf wheat with wide adoption and recommended for cultivation all over India. Developed by bulking the brown rust resistant segregates from Mexican
Sample 227, emanating from the cross (Fm-K58-New Thatch x Norin 10-Brever) x Gabe 55. Grains are umber, hard and medium in size. Highly resistant to loose smut, striking smut and tolerant to powdery mildew and alternaria leaf blight.

2. **Sonalika** (HD 1553)

An early maturing single dwarf wheat with wide adoption and good attractive umber grains developed from the Mexican cross (1154-386-Am) x (Yt 54X Norin 10B) LR III6427. It is recommended for cultivation in the north-western, north-eastern and peninsular zones but is grown in northern hills and central zone also. The variety is very suitable for late sowing and is resistant to rusts. While S308 is the original material received from Mexico and its further selections are known as Sonalika (R.R.21) or Sonalika (HD 1553).

3. **Heera** (HD 1941)

It is a triple dwarf wheat released on commercial scale in this country, particularly suited for north-western plains zone for normal sowing under high fertility conditions. It is developed by crossing Peetics x Sonora 64 and is tolerant to stem rust and resistant to yellow rust. Grains are medium bold, umber, hard and is medium early in maturity.
4. **Mott** (MH 1949)

It is a triple dwarf early maturing wheat recommended for northern India. It escapes attack of rusts. The grains are umber and hard.

7. **SOWING**

After final field preparation, lay-out and basal fertilizer application, planting of two seeds per hole at 10 cm apart in lines spaced 20 cm apart was done in the third week of November in the two seasons.

8. **APPLICATION OF MULCH**

The treatment of mulch was imposed immediately after the maintenance of uniform plant stand and also interculture and weeding on the 14th day after seeding. In case of sand and saw dust mulches 1.25 cm thick layer of each of the material was spread all over the plot. In case of polyethylene, 200 gauge thick sheet was spread all over the plot and the individual plants were taken out of the sheet cover by making small incisions with a blade at the individual plant's position. The sheet was pressed and brought in contact with soil. This provided perfect coverage of the land surface more or less similar to that of other treatments of mulches. These incisions were also made at places where the tensiometers were installed and also from where soil samples were taken for moisture determination. These holes were later on filled up with soil and covered by pasting small pieces of plastic sheet.
9. **IRRIGATION**

Irrigation was applied at 50% depletion of the available soil water from 0-30 cm soil depth. Soil water depletion up to 50% was chosen because this was considered to be maximum allowable depletion without affecting the final yield of wheat under such conditions (Bathkal and Dastane, 1968). Use of minimum possible water was another important consideration. The depletion was read on the calibrated soil moisture tensiometers installed in each plot in a replicate.

The quantity of water applied was determined as per the procedure of Israelson and Hansen (1962) and the water was applied through a 5 cm diameter polyethylene pipe fitted directly to an engine set. The quantity was regulated by the discharge and the time of run of the pump. Irrigation in case of polyethylene mulch was applied below the polyethylene sheet and enough precaution was taken to see that total amount of applied water reaches all over the ground surface. The spray of fertilizer was adjusted with irrigation also so that the spray particles retained on the polyethylene sheet were taken to the soil surface through irrigation water partly applied over plastic surface for the purpose.
Table 2. The exact dates of irrigations in field trial.

<table>
<thead>
<tr>
<th>Irrigation Number</th>
<th>No mulch</th>
<th>Sand</th>
<th>Saw dust</th>
<th>Polyethylene</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1971-72</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>5.12.71</td>
<td>5.12.71</td>
<td>5.12.71</td>
<td>5.12.71</td>
</tr>
<tr>
<td>II</td>
<td>20.12.71</td>
<td>15.1.72</td>
<td>19.1.72</td>
<td>21.1.72</td>
</tr>
<tr>
<td>III</td>
<td>10.1.72</td>
<td>4.2.72</td>
<td>21.2.72</td>
<td>16.3.72</td>
</tr>
<tr>
<td>IV</td>
<td>1.2.72</td>
<td>1.3.72</td>
<td>25.3.72</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>24.2.72</td>
<td>19.3.72</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VI</td>
<td>18.3.72</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VII</td>
<td>28.3.72</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total irrigation</strong></td>
<td><strong>7</strong></td>
<td><strong>6</strong></td>
<td><strong>4</strong></td>
<td><strong>3</strong></td>
</tr>
<tr>
<td><strong>1972-73</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>28.1.73</td>
<td>6.2.73</td>
<td>16.2.73</td>
<td>6.3.73</td>
</tr>
<tr>
<td>III</td>
<td>16.2.73</td>
<td>3.3.73</td>
<td>16.3.73</td>
<td>29.3.73</td>
</tr>
<tr>
<td>IV</td>
<td>10.3.73</td>
<td>20.3.73</td>
<td>31.3.73</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>24.3.73</td>
<td>2.4.73</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VI</td>
<td>6.4.73</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total irrigation</strong></td>
<td><strong>6</strong></td>
<td><strong>5</strong></td>
<td><strong>4</strong></td>
<td><strong>3</strong></td>
</tr>
</tbody>
</table>
I. GROWTH AND YIELD STUDIES

(A) GROWTH STUDIES

Following growth observations were recorded at monthly intervals starting from 15th day of crop till the harvest.

1. PLANT STAND

On 14th day of seeding individual hills were counted and gaps, if any, filled by transplanting so as to achieve uniform plant stand. Final stand was counted at the harvest.

2. PLANT HEIGHT

Three plants randomly selected from each plot were marked for making height measurements in situ. The height of each main shoot till the ear initiation stage was measured from ground level to the base of the last leaf of the plant while after the ear initiation from the ground level to the basal portion of the ear. Average of the three plants was reported as the height of the plant in a particular treatment.

3. NUMBER OF SHOOTS

From the plants randomly marked for taking plant height, all green shoots were counted as the number of shoots per plant. Average of the three was reported as the number of shoots per plant/hill.
4. NUMBER OF FUNCTIONING LEAVES

All green leaves of the above three plants selected for height measurements were counted and averaged for reporting the number of functioning leaves/hill.

5. LEAF AREA INDEX (LAI)

Leaves of the three plants randomly uprooted from the outer 1 m of each plot were graded into different categories based on their sizes and shapes. The area of one leaf from each category was measured with the help of a planimeter. This area then multiplied by the number of leaves in that category and all categories added together gave the total leaf area. The average of the three plants gave average leaf area per plant. For final reporting LAI was worked out as the ratio between the total leaf area and the land area occupied by the plant.

6. DRY MATTER PRODUCTION

Three plant samples collected for leaf area measurements were dried in sun and then in an electric oven at 90°C till constant weight. Average of the three plants was considered as dry matter production per plant. The total dry matter production per hectare was calculated on the basis of per plot dry matter harvest.
7. DATE OF EAR EMERGENCE

The date when about 50% or more of the plants in a metre row length, randomly marked at three places in each plot, showed ear initiation was recorded as the date of ear emergence.

(b) YIELD STUDIES

1. NUMBER OF EAR BEARING SHOOTS

Three randomly marked plants in each plot were harvested and the ear bearing shoots were counted from each plot. Average of the three plants was considered as number of ear bearing shoots per plant for reporting.

2. GRAIN YIELD

Bulk harvest from net plot was threshed for grain. Grain yield thus obtained from individual plot was converted to q/ha and reported at 12% moisture content.

3. STRAW YIELD

Grain yield subtracted from the total dry matter (dry produce) weight gave the total yield of straw. The yield per plot was converted to q/ha and reported at 14% moisture content.

4. LENGTH OF THE EAR

The length of the individual ears from the main shoots of three randomly selected plants was measured and totalled. The sum total divided by the total number of ears gave the average length of the ear for reporting.
5. NUMBER OF SPIKELETS

Number of spikelets were counted from three randomly selected ears from each plant. Average of 9 ears was considered as average number of spikelets per ear.

6. WEIGHT OF 1000 GRAINS

A composite sample from the bulk harvested was used for counting 1000 grains. The weight of these grains was reported as weight of 1000 grains.

II. NUTRIENT STUDIES

1. NUTRIENT UPTAKE

At various crop growth stages starting from 30 days of seeding till harvest, plants were analysed for nitrogen content by modified micro-kjeldahl method. Straw and grain were analysed separately for nitrogen, phosphorus and potash contents. Phosphorus was determined by photo-electric calorimeter and potash by flamephotometer method. The total uptake of nitrogen, phosphorus and potash were calculated on hectare basis in kg by multiplying the concentration (%) of each nutrient with that of total yield.

2. NITROGEN USE EFFICIENCY (NUE)

The coefficient of efficiency of productivity (E) by use of nitrogen normally called nitrogen use efficiency was calculated as follows:

\[ E = \frac{Y_n - Y_{n-1}}{X_n - X_{n-1}} \]
Where \( Y_n - Y_{n-1} \) = Dry matter (grain yield) at \( n \) and \( n-1 \) stages.

\( X_n - X_{n-1} \) = Nitrogen absorbed at \( n \) and \( (n-1) \) stages.

III. MOISTURE STUDIES

1. TOTAL AND AVAILABLE WATER CONTENT IN SOIL

The total and available water content in soil were determined as per the procedure given by Binkowski (1961).

\[
\begin{align*}
W_t &= \frac{(W_s - D_s) \times T \times Bd}{D_s} \\
W_a &= (W_t - Pwp)
\end{align*}
\]

Where

- \( W_s \) = Sample weight of field moisture content (g)
- \( D_s \) = Dry weight of soil sample (g)
- \( T \) = Thickness of sample (cm)
- \( Bd \) = Bulk density \( g/cm^3 \)
- \( Pwp \) = Moisture content at wilting point (cm)
- \( W_a \) = Available water content (cm)
- \( W_t \) = Total water content (cm)

2. CONSUMPTIVE USE OF WATER

Seasonal consumptive use (Cu) was calculated with the help of following formula (Bastane, 1970):

\[
Cu = \frac{N}{K-th} \times (E_p \times 0.8) + \frac{B}{i-th} \times \frac{(M1-M2)}{100} \times A_s \times D_i + ER
\]
Where

\[ \begin{align*}
E_p &= \text{Evaporation from pan evaporimeter.} \\
M_1 &= \text{Soil moisture \% after irrigation when sampling is possible.} \\
M_2 &= \text{Soil moisture \% just before next irrigation.} \\
A_{si} &= \text{Apparent specific gravity of } i\text{-th layers of the soil.} \\
D_i &= \text{Depth of } i\text{-th layers.} \\
E_R &= \text{Effective rainfall} \\
R_{i-th} &= \text{Number of layers to be considered.} \\
N_{k-th} &= \text{Number of irrigations applied} \\
\end{align*} \]

Total moisture content was determined from 0-60 cm depth. Irrigation water applied and the effective rainfall received was used for calculating the seasonal consumptive use. The deep percolation and ground water contribution was negligible due to the presence of ground water table below 2.5 metres from the surface. Daily consumptive use was determined by dividing the total consumptive use for a particular period with number of days in that period.

3. WATER USE EFFICIENCY (WUE)

The water use efficiency was worked out as the ratio between the total dry matter (Y) and the water used in evapotranspiration (ET) at different stages of crop growth. At harvest the WUE was calculated on grain yield basis.

or \[ \text{WUE} = \frac{Y}{ET} \]
Where

\[ Y = \text{Yield of marketable produce of crop.} \]

\[ ET = \text{Evapotranspiration or seasonal water use.} \]

4. SOIL MOISTURE DEPLETION PATTERN

The values of soil moisture depletion from different depths between different irrigation cycles were totalled for specific growth period. The per cent contributions stagewise and depthwise have been computed.

5Y. ECONOMICS OF THE EXPERIMENTS

The produce under different treatments was converted into rupee values for comparisons. The rates of different products used for these calculations were Rs.110/q grain and Rs.22/q straw, the average rates of the seasons prevailing at that time.

STATISTICAL ANALYSIS

The data observed were analysed statistically as per procedure described by Panse and Sukhatme (1967) and multiple regression equation as per procedure of Snedcor (1959). The response of grain yield to nitrogen uptake and consumptive use of water was studied by fitting response curve. The following linear, quadratic and second degree polynomial response equations were used for yield, nitrogen uptake and consumptive use of water relationship.
\[ Y = a + b x^2 \quad \ldots \ldots \quad (A) \]
\[ Y = a + B x + C x^2 \quad \ldots \ldots \quad (B) \]
\[ Y = a + b_1 x_1 + b_2 x_2 + b_3 x_1^2 + b_4 x_2^2 + b_5 x_1 x_2 \quad \ldots \quad (C) \]

Where \( Y \) is the grain yield of wheat corresponding to the \( X \) level of nitrogen uptake or consumptive use of water and \( a, b, \) and \( c \) are the constants for equation \( (A) \) and \( (B) \). In equation \( C, Y \) is the grain yield of wheat, \( x_1 \) is nitrogen uptake and \( x_2 \) is consumptive use of water, \( a \) is pure content and \( b_1, b_2, b_3, b_4 \) and \( b_5 \) are the regression coefficients. These equations were extended to compute yield maxima and economic optima as per the procedure given by Heady and Dillon (1969). The data were processed through Computer (IBM 1620) at the Institute of Agricultural Research Statistics, New Delhi.