4.1 Collection of secondary data

Data on area, production and yield of major agricultural crops grown in Jaintia Hills District have been collected from Directorate of Economics and Statistics, Govt. of Meghalaya. Land use statistics of Jaintia Hills District were also collected for the same period. Data was analyzed to determine the extent of land degradation and impact of land used for various activities on agriculture of the region.

4.2 Analysis of secondary data on land use

Land Use statistics of Jaintia Hills District, Meghalaya were collected since 1987-88 till 2001-02. Contribution of each category of land use to the total geographical area of the district has been expressed in per cent. The period from 1987-88 to 2001-02 has been divided into five blocks of three years each i.e. A (1987-88 to 1989-90), B (1990-91 to 1992-93), C (1993-94 to 1995-96), D
(1996-1997 to 1998-99) and E (1999-2000 to 2001-2002). The block wise variation of land use has been calculated as follows:

\[ \frac{100(B-A)}{A} = \text{Variation during B block over A block} \]
\[ \frac{100(C-B)}{B} = \text{Variation during C block over B block} \]
\[ \frac{100(D-C)}{C} = \text{Variation during D block over C block} \]
\[ \frac{100(E-D)}{D} = \text{Variation during E block over D block} \]
\[ \frac{100(E-A)}{A} = \text{Variation during E block over A block} \]

4.3 Analysis of secondary data on area, production and yield of agricultural crops

Agricultural crops were categorized as foodgrains, oilseeds and horticultural crops. The long-term average was calculated with respect to area, production and yield of different categories of agricultural crops. Average annual change (%) of area, production and yield of agricultural crops was calculated as follows:

\[
\text{Average annual change(%) } = \frac{\sum_{t} \{ \frac{(\text{Area/Production/Yield of (a given year - previous year)} \times 100}{\text{Area/Production/Yield of previous year}} \}}{n}
\]

Where,

\[ n = \text{Number of years} \]

Percentage of net sown area occupied by different crops has been calculated. Block wise variation of area, production and yield of different crops have been calculated with the same procedure followed for land utilization.
4.4 Analysis of physico-chemical properties of soil of study area

Soil samples were collected using cores from the rice fields of three coal mining sites of Jaintia Hills District namely Dkhiah, Lad-Rymbai and Bapung. All sampling locations are situated at a height of about 1,200-1,300 m above mean sea level. Composite soil samples were collected from the field before experimentation to a depth of 0-15 cm and subjected to various physical and chemical analysis such as soil texture, soil pH, available nutrients (kg/ha) and organic carbon (%) following standard procedures (Table 4.1) separately for all the locations. Available nutrients were determined in parts per million (ppm), which were later converted in to kg/ha by multiplying with a factor 2.24 (Subbiah and Asija, 1956; Bray and Kurtz, 1945).

Table 4.1: Methods followed for analysis of various parameters of soil

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Methods used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil texture</td>
<td>Hydrometer method (Bouyoucos, 1962)</td>
</tr>
<tr>
<td>Soil pH</td>
<td>pH meter (1:2.5 :: soil: water)</td>
</tr>
<tr>
<td>Available Nitrogen</td>
<td>Alkaline Potassium Permanganate method</td>
</tr>
<tr>
<td></td>
<td>(Subbiah and Asija, 1956)</td>
</tr>
<tr>
<td>Available Phosphorous</td>
<td>Bray's method (Bray and Kurtz, 1945)</td>
</tr>
<tr>
<td>Available Potassium</td>
<td>Ammonium Acetate extraction for exchangeable potassium</td>
</tr>
<tr>
<td></td>
<td>(Flame photometric method)</td>
</tr>
<tr>
<td>Organic carbon</td>
<td>Titrimetric method (Walkley and Black, 1934)</td>
</tr>
</tbody>
</table>
4.5 Evaluation of rice varieties in mine affected soil

A pot experiment was conducted to evaluate tolerant rice varieties for cultivation on mine affected soil under various remedial measures. The experiment was conducted in ICAR Research Complex for NEH Region, Umiam, Meghalaya during kharif seasons (June-September) of 2005 and 2006. Meteorological data of study area (Jaintia Hills) and experimental site (Umiam) for 2005 and 2006 is given in Appendix 1 and Appendix 2, respectively.

4.5.1 Selection of rice varieties

Three different rice varieties namely Khaw Saw, Bhalum-1 and Bhalum-2 were selected for growing in pots. Out of the three varieties Khaw Saw is widely grown in Jaintia Hills. The yield of this variety is only 1-2 tonnes/ha as reported by the local farmers. Other two varieties namely Bhalum-1 (RCPL 1-27) and Bhalum-2 (RCPL 1-29) have been collected from ICAR Research Complex for NEH Region, Umiam (Shillong). These two varieties were recommended for upland conditions of medium altitude (800-1,300 above mean sea level) areas of Meghalaya (Anonymous, 2001).
4.5.2 Treatments

Soil samples obtained from mining area were treated with organic matter and lime in different combination as given below:

1. **T1**: Control (Without application of any soil amendment)
2. **T2**: Organic matter (10 t/ha or 178.6 g/pot)
3. **T3**: Lime (4.08 t/ha or 72.9 g/pot)
4. **T4**: Organic matter (10 t/ha) + Lime (4.08 t/ha)

4.5.3 Experimental Design and layout

The layout (Table 4.2) consisted of 36 pots laid out in a Completely Randomized Design (CRD) with three replications.

<table>
<thead>
<tr>
<th>Variety</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatments</td>
<td>4</td>
</tr>
<tr>
<td>Replications</td>
<td>3</td>
</tr>
<tr>
<td>Total number of pots</td>
<td>$3 \times 4 \times 3 = 36$</td>
</tr>
</tbody>
</table>

Table 4.2: The experimental layout with different treatments

<table>
<thead>
<tr>
<th>V1F0L0</th>
<th>V2F0L0</th>
<th>V3F0L0</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1F0L1</td>
<td>V2F0L1</td>
<td>V3F0L1</td>
</tr>
<tr>
<td>V1F1L0</td>
<td>V2F1L0</td>
<td>V3F1L0</td>
</tr>
<tr>
<td>V1F1L1</td>
<td>V2F1L1</td>
<td>V3F1L1</td>
</tr>
</tbody>
</table>
Where,

- \( V1 \) = Khaw Saw rice variety
- \( V2 \) = Bhalum 1 (RCPL 1-27)
- \( V3 \) = Bhalum 2 (RCPL 1-29)
- \( F0 \) = No application of FYM
- \( F1 \) = FYM (178.6 g/pot)
- \( L0 \) = No application of lime
- \( L1 \) = Lime (4.08 g/pot)

**4.5.4 Seed treatment**

Seeds were soaked with 0.1% Bavistin prior to sowing as preventive measures against diseases. Crops were sprayed with 0.05% Monocrotophos to reduce the insect population.

**4.5.5 Sowing**

Each pot was filled with 4 kg of soil. 5-6 seeds were sown per pot. Sowing was done on 28/05/2005 and 8/5/2006 for the two years of experiments, respectively.

**4.5.6 Cultural operations**

Cultural operations like weeding and thinning were carried out manually. Weeding was done at regular intervals during the crop growth and the thinning
was carried out 20-25 days after sowing to maintain required plant population of one plant per pot.

4.5.7 Watering

The pots were continuously watered to maintain about 5 cm of standing water throughout the growth period till reaching maturity stage.

4.5.8 Fertilizer application

In all treatments common doses of fertilizer (60kg N: 60kg P: 40kg K) were applied (Table 4.3). Nitrogenous, phosphatic and potassic fertilizers were applied in the forms of urea, single super phosphate (SSP) and muriate of potash (MoP), respectively. Amount of fertilizer required for each pot was calculated for 4 kg soil per pot, considering weight of soil for 1 ha land is equivalent to $2.26 \times 10^6$ kg.

Table 4.3: Amount of fertilizer applied in pots

<table>
<thead>
<tr>
<th>Fertilizer</th>
<th>kg/ha</th>
<th>g/pot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urea</td>
<td>130.43</td>
<td>0.23</td>
</tr>
<tr>
<td>Single Super Phosphate (SSP)</td>
<td>375.00</td>
<td>0.67</td>
</tr>
<tr>
<td>Muriate of Potash (MoP)</td>
<td>67.00</td>
<td>0.12</td>
</tr>
</tbody>
</table>
Half dose of urea and full doses of SSP and MoP were applied at the time of filling the pots with soil, i.e. just before sowing, while remaining urea was top-dressed at panicle initiation stage of the crop growth.

4.5.9 Farmyard Manure (FYM): The basic ingredient of this manure is animal excreta. Content of major nutrients in FYM is 0.5% Nitrogen, 0.3% P₂O₅ and 0.5% K₂O (Biswas and Mukherjee, 1997). FYM was applied at the rate of 10 t/ha or 178.6 g/pot before sowing of seeds.

4.5.9.1 Calculation for amount of FYM applied in the treatment

1 ha land is equivalent to 2.26 x 10⁶ kg soil.

Again, 2.26 x 10⁶ kg soil requires 10 tonnes of FYM.

Hence, 4 kg soil (per pot) requires (10 x 4)/(2.26 x 10⁶) tonnes FYM or 178.6 g FYM.

4.5.10 Lime

Calcium Carbonate (CaCO₃) was applied as liming material. Lime was applied at the rate of 4.08 t/ha or 72.9 g/pot to bring the pH of the soil up to 6 (Shoemaker et al., 1961).
4.5.10.1 Calculation for lime application

1 ha land is equivalent to $2.26 \times 10^6$ kg soil.

$2.26 \times 10^6$ kg soil requires 4.08 tonnes of CaCO$_3$.

So, 4 kg soil (per pot) requires $(4.08 \times 4)/(2.26 \times 10^6)$ tonnes Lime or 72.9 g lime.

4.6 Measurement of growth and yield parameters

Measurement of various growth and yield parameters such as phenological stages, plant height, Leaf area Index (LAI), biomass yield, various yield components and grain yield were periodically recorded using standard procedure (Table 4.4).

4.6.1 Phenology: The standing crop was observed periodically to determine the occurrence and duration of various phenological stages. From these observations, seedling emergence (SE), start tillering (ST), panicle emergence (PE), milk, dough and maturity stages were identified. The first two stages make the vegetative phase of rice. Other stages from panicle emergence to maturity correspond to ripening stage of the crop.

4.6.2 Plant height: Plant height was measured with the help of a meter scale at 7 days interval from tillering to physiological maturity.
4.6.3 Leaf Area Index (LAI): This is the ratio between total green leaf area to ground area occupied by the plants. LAI was measured with plant canopy imager (CI-110) at various crop stages (Anonymous, 2003).

4.6.4 Yield components: Yield components of rice recorded are as given below:

a) Number of effective tillers: These are the tillers with filled grains.

b) Number of filled grains per panicle

c) 1,000 grain weight (g): This is the weight of 1,000 grains of a particular treatment.

Above parameters were measured by manual method (Yoshida et al., 1976).

Table 4.4: Measurement of various plant growth parameters:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Methodology</th>
<th>Time interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phenological stages</td>
<td>Visual observation</td>
<td>From seedling emergence to yellow maturity</td>
</tr>
<tr>
<td>Plant height</td>
<td>Manual method (Yoshida et al., 1976)</td>
<td>From tillering to physiological maturity on weekly basis</td>
</tr>
<tr>
<td>Leaf Area Index</td>
<td>Plant Canopy Imager (CI-110) (Anonymous, 2003)</td>
<td>At various crop growth stages</td>
</tr>
<tr>
<td>Yield components</td>
<td>Manual method (Yoshida et al., 1976)</td>
<td>At maturity</td>
</tr>
<tr>
<td>Grain yield</td>
<td>Physical balance (Yoshida et al., 1976)</td>
<td>At maturity</td>
</tr>
<tr>
<td>Dry matter production</td>
<td>Conventional oven drying method (Yoshida et al., 1976)</td>
<td>At maturity</td>
</tr>
</tbody>
</table>
4.6.5 Measurement of grain yield

The grains obtained from a particular pot were threshed, cleaned, dried and weighed. Total weight of all the grains of a particular pot gives the grain yield per pot.

4.6.5.1 Conversion of grain yield per pot to grain yield for one ha area (kg/ha)

It is assumed that plant density of 1 m² area is 25 with 20cm x 20cm spacing. Hence, 1 ha (10,000 m²) area has a plant density of 2,50,000 with same spacing.

\[
\text{Grain yield (kg/ha)} = \frac{\text{Grain yield per pot} \times 2,50,000}{1,000}
\]

4.6.6 Biomass: Above ground plant materials were collected after harvest and oven dried at 65 °C until a constant weight was obtained to determine dry biomass production.

4.6.7 Harvest Index: Harvest index of crop is a good indicator of its productivity performance. It is calculated using the following formula:

\[
\text{Harvest Index (HI)} = \frac{\text{Total grain yield}}{\text{Total dry matter production}}
\]
4.7 Statistical analysis

Standard statistical procedures were employed for analysis and interpretation of data (Gomez and Gomez, 1984). ANOVA analysis was done using MSTAC software developed by International Rice Research Institute (IRRI), Philippines.

4.8 Comparison of different varieties

From the analysis of different growth and yield parameters, the varieties have been ranked according to their performance as obtained from standard statistical analysis. The three ranks viz. 1, 2 and 3 were assigned to the varieties pertaining to any given parameter depending on their recorded level in descending order of magnitude, except, in case of attainment of yellow maturity. Here, the shorter duration to attain maturity has been considered as a positive character and no. 1 ranking is given to the variety, which has shown shortest duration of crop cycle. Again, in certain cases same ranking has been assigned to two or more varieties, which indicate that for that particular parameter the varieties do not differ significantly. The variety which ranked first (1st) in maximum number of parameters has been considered best and recommended for cultivation in coal mine affected soil of the study area.