Effects of Arbuscular Mycorrhizal Fungi inoculation in Maize (Zea mays L.) on plant growth parameters and yield attribute of Maize in Limestone Mine Spoils of Mawsmai, Meghalaya.

Evaluation of plant growth parameters and yield attribute of Maize (Zea mays L.) through arbuscular mycorrhizal fungi assisted remediation under maize cowpea intercropping system in limestone mine spoils of Mawsmai, Meghalaya

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**Key Words**: limestone, mawsmai, meghalaya, mine spoils, phytological, plant species

**Abstract**

**Introduction**

**Materials and Methods**

The field experiment was conducted by following standard agronomic practices of cultivation during *kharif* season in limestone mining area of Mawsmai, Sohra (Cherrapunjee) Meghalaya. The study area lies in the south-western part at 25°15’N latitude, 91°43’E longitude and elevation of the study site varies between 1221-1263 m above the mean sea level (Figure 1).

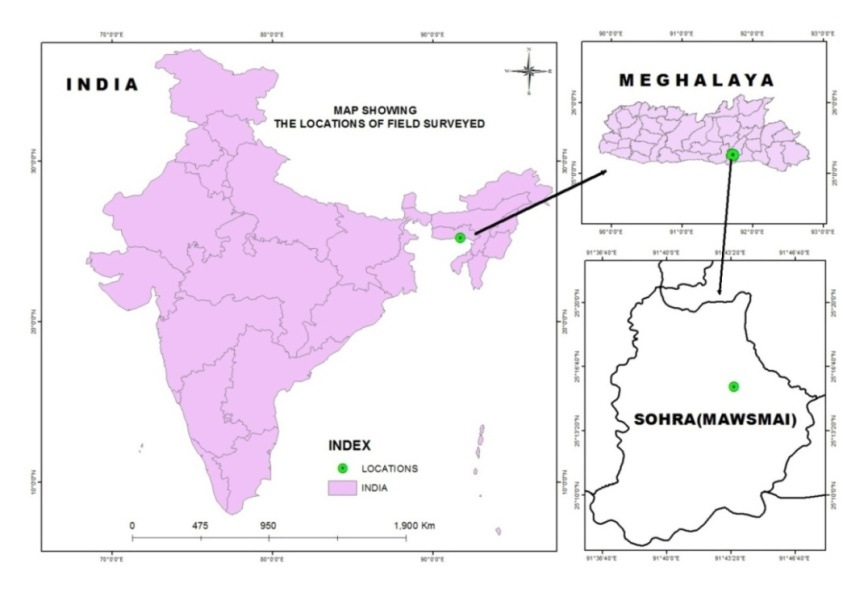


Figure 1 Map showing location of the study area

Maize (*Zea mays* L.) RCM-76 variety intercropped with cowpea (*Vigna unguiculata* L.) Khasi Kanchan variety were chosen as model crops for field trial experiment as these two agricultural crops are excellent and compatible performance crops for rejuvenation of the disturbed ecosystem. Maize plant was chosen as a symbiotic partner, because of its high mycorrhizal dependency, high germination percentage, early susceptibility to mycorrhizal colonization and abundant root production (Liu and Wang, 2003). Cowpea is also an excellent leguminous crop for nitrogen fixation, recent research has shown that the association of cereals and legumes can increase yields and improve N and P uptake via the biological fixation of N2 and chemical changes within the root zone (Betencourt *et al*., 2012; Latati *et al*., 2013). These two crops are also commonly cultivated by farmers of Mawsmai village in agricultural fields as a source of livelihood.

**Climate and weather condition during experimental period**

The village of Mawsmai, Sohra (Cherrapunjee) experienced a sub-tropical type of climate with high rainfalls and cold winters. Cherrapunjee and Mawsynram, located in the southern part receive the highest rainfall in the world with an average annual rainfall of 11,820 mm. There is a marked seasonal variation in rainfall distribution as more than 80% share of annual rainfall is precipitated in summers (May-September). The total rainfall received during the study period was 7189.20 mm. The maximum rainfall of 2053.60 mm was recorded during the month of July. The maximum and minimum temperature recorded during the cropping season ranged from 24.6°C and 18.5°C respectively. Relative humidity ranged from 78% to 95% during the experimental period (Figure 2).

Figure 2 Climatogram showing mean monthly variation of air temperature, relative humidity and rainfall of the study area during the year 2018 (Source Indian Meteorological Department)

**Land and crop history**

The experimental land was remaining fallow and no agricultural crop has been cultivated since mining activities started in the area. The configuration of the plots used for the experiment was a mid-hill bench terrace. The land was leveled before starting the field experiment. The experiment was conducted in limestone mine spoils of less than 8 years (LMS8) site considering the optimum vegetational successional stage and edaphic factors taken into consideration for early management intervention of the abandoned mine spoils for rejuvenation and restoration of the degraded ecosystem (Figure 3).

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| --- | --- |
| F:\Gary Photos\IMG_20170708_165104.jpg  Figure 3 (a, b) Land preparation for field experimental trial with isolated native AMF species in limestone mine spoils  **a** | IMG_20170708_165111.jpg  **b** |

**Experimental details**

The experiment was carried out using Randomized Block Design (RBD) with 4 replications for each treatment. The treatment blocks were perpendicular to the slope/altitude of the experimental site. There were 44 plots with an individual size of (4 x 3) m2. The treatment layout of the experiment of the various plots and the pattern of planting of the crops in the experimental field is indicated in Figure 4. Maize intercropped with cowpea was sown in the prepared plots on the 27th April, 2018.

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**S**

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**MCT7**

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Figure 4 Randomized block design of the experimental site

**Table 1. Treatment with native Arbuscular Mycorrhizal Fungi (AMF) in combination with inorganic fertilizers and top soil from community protected forest**

|  |  |  |
| --- | --- | --- |
| **LEGEND** | |  |
| Maize + Cowpea | | MC |
| **Treatment** | |  |
| i. | Control (no inputs) | T0 |
| ii. | *Funneliformis mosseae* AMF inoculum | T1 |
| iii. | *Rhizophagus intraradices* AMF inoculum | T2 |
| iv. | *Septoglomus constrictum*. AMF inoculum | T3 |
| v. | *F. mosseae* + *R. intraradices+ S. constrictum* inocula | T4 |
| vi. | 50% RDF + *F. mosseae* | T5 |
| vii. | 50% RDF + *R.intraradices* | T6 |
| viii. | 50% RDF + *S. constrictum* | T7 |
| ix. | 50% RDF + *F. mosseae* + *R. intraradices* + *S. constrictum* | T8 |
| x. | Recommended dose of inorganic fertilizers (NPK) 100% | T9 |
| xi. | Top soil from community protected Forest | T10 |

**Table 2. Inputs and cultural practices followed for field experiment trial**

|  |  |  |  |
| --- | --- | --- | --- |
| **Sl. No.** | **Cultural operations** | **Crops** | **Date of operation** |
| 1 | Field preparation | Maize | 25th& 26th March, 2018 |
| Cowpea | ……..do……. |
| 2 | Field layout | Maize | 7th, April, 2018 |
| Cowpea | ……..do……. |
| 3 | FYM applications (tons ha-1) | Maize | 10 tons ha-1  12th, April, 2018 |
| Cowpea | ……..do……. |
| 4 | Fertilizer dose  (N: P2O5: K2O in kg ha-1) | Maize | 80: 60: 30 |
| Cowpea | 20: 40: 30 |
| 5 | Variety sowed | Maize | RCM-76 |
| Cowpea | Khasi kanchan |
| 6 | Date of sowing | Maize | 27th, April, 2018 |
| Cowpea | ……..do……. |
| 7 | Spacing (cm) | Maize | 50 x 20 cm r-r and p-p |
| Cowpea | 30 x 50 cm r-r and p-p |
| 8 | Date of harvesting | Maize | 23rd, Sept., 2018 |
| Cowpea | ……..do……. |

**Soil physico-chemical and biological characteristics**

Soil physico-chemical properties and biological properties *viz.,* soil pH, electrical conductivity, moisture content, bulk density, maximum water holding capacity, soil mean weight diameter, exchangeable Ca + Mg, available nitrogen, available phosphorous, organic carbon, microbial biomass carbon, total glomalin, AMF spore density and AMF root colonization were determined as per standard methods given in Table

**Table 7.1.** Initial physico-chemical and biological characteristics of soil in the experimental site

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sl. No. | Particulars | Value | Method adopted | Inferences |
| 1. Physical Properties | | | | |
|  | Soil texture   1. Sand (%) 2. Silt (%) 3. Clay (%) | 74.99  15.00  10.00 | International Pipette Method (ISSS,1929) | Sandy loam |
|  | Soil temperature (°C) | 21.04 | Soil Thermometer | High |
|  | Moisture content (%) | 7.28 | Gravimetric Method | Low |
|  | Bulk density (g cc-1) | 1.10 | Clod Method (Blake, 1965) | High |
|  | Maximum water holding capacity (%) | 46.14 | Keen Raczkowski Box (Baruah and Borthakur, 1999) | Low |
|  | Soil mean weight diameter (mm) | 2.28 | Yoder Wet Sieving Method (Black, 1965 and Russel, 1949). | Low |
| 1. Chemical Properties | | | | |
|  | Soil pH (1:2.5 soil water suspension) | 7.98 | Glass Electrode (Jackson, 1973) | High |
|  | Soil EC (µS cm-1) at 25°C | 391.33 | Conductometry (Jackson, 1973) | High |
|  | Organic carbon (%) | 0.41 | Dichromate Wet Oxidation (Walkey and Black, 1934) | Low |
|  | Soil available nitrogen  (kg ha-1) | 250.58 | Alkaline Permanganate (Subbiah and Asija, 1956) | Low |
|  | Soil available phosphorous  (kg ha-1) | 8.81 | Olsen’s Method (Olsen *et al*., 1954) | Low |
|  | Soil available potassium  (kg ha-1) | 144.15 | Flame Photometry Method (Hanway and Heidel, 1952). | Low |
|  | Exchangeable Ca+Mg  (meq 100-1 g soil) | 14.21 | EDTA Titration (Black, 1965). | High |
|  | Calcium carbonate (%) | 22.57 | Standard Titration Method (Schollenberger, 1945) | High |
|  | DTPA extractable Zn (ppm) | 0.26 | DTPA extraction method (Lindsay and Norvell (1978) | Low |
|  | DTPA extractable Fe (ppm) | 1.61 | …………do………. | Low |
|  | DTPA extractable Cu (ppm) | 0.16 | …………do………. | Low |
|  | DTPA extractable Mn (ppm) | 1.57 | …………do………. | Low |
| 1. Biological Properties | | | | |
| 1. | Microbial biomass carbon  (μg g-1) | 161.85 | Chloroform Fumigation Extraction Method (Brookes and Joergensen, 2006). | Low |
| 2. | Total glomalin related soil protein (mg g-1) | 3.26 | Bradford Method (Wright and Upadhyaya, 1998) | Low |

**Statistical analysis**

The data was analysed by one-way analysis of variance (ANOVA) incorporating Duncan’s multiple range test (DMRT) at 5% level of significance for pair wise comparison between means. Statistical analysis was performed using SPSS v21 (IBM, SPSS, 2012).

**Results and Discussion**

**Plant height**

The mine spoils had averaged maize plant height of 112.24 cm**,** however however on replacement of mine spoiled soil by top soil of community protected forest (T10) plant height increased significantly by 33%. We also observed an increased by (30.63 to 17.38%) in plant height of mine spoiled soils by other management interventions like adopting inorganic fertilizers (NPK @100 RDF) (T9) and 50% RDF + *S. constrictum* (T7) over T0 (Figure 7.18.). The pair wise comparison between treatments mean was statistically significant (*p* < 0.05) in T10 and T9 (Table 7.5.).

**Dry matter production per plant**

The mine spoils had averaged dry matter production of 113.50 g per plant, however on replacement of mine spoiled soil by top soil of community protected forest (T10) dry matter production per plant increased significantly by 78.73%. We also observed an increased by (69.58 to 33.75%) in dry matter production per plant of mine spoiled soils by other management interventions like adopting inorganic fertilizers (NPK @100 RDF) (T9) and 50% RDF + *F. mosseae* + *R. intraradices* + *S. constrictum* (T8) over T0 (Figure 7.19.). The pair wise comparison between treatments mean was statistically significant (*p* < 0.05) in T10 and T9 (Table 7.5).

**Number of cobs per plant**

The mine spoils had averaged number of cobs of 1.74 per plant, however on replacement of mine spoiled soil by top soil of community protected forest (T10) the number of cobs per plant increased significantly by 59.45%. We also observed an increased by (54.05 to 8.10%) in number of cobs of mine spoiled soils by other management interventions like adopting inorganic fertilizers (NPK @100 RDF) (T9) and 50% RDF + *F. mosseae* + *R. intraradices* + *S. constrictum* (T8) over T0 (Figure 7.20.). The pair wise comparison between treatments mean for number of cobs per plant was statistically significant (*p* < 0.05) in T10 and T9 (Table 7.5.).

**Cob length**

The mine spoils had averaged cob length of 7.79 cm, however on replacement of mine spoiled soil by top soil of community protected forest (T10) cob length increased significantly by 38.25%. We also observed an increased by (26.95 to 8.47%) in cob length of mine spoiled soils by other management interventions like adopting inorganic fertilizers (NPK @100 RDF) (T9) and 50% RDF + *R. intraradices* (T6), over T0 (Figure 7.21.). The pair wise comparison between treatments mean was statistically significant (*p* < 0.05) in T10 and T9 (Table 7.5.).

**Cob diameter**

The mine spoils had averaged cob diameter of 4.46 cm, however on replacement of mine spoiled soil by top soil of community protected forest (T10) cob diameter increased significantly by 69.73%. We also observed an increased by (66.81 to 32.28%) in cob diameter of mine spoiled soils by other management interventions like adopting inorganic fertilizers (NPK @100 RDF) (T9) and 50% RDF + *F. mosseae* (T5) over T0 (Figure 7.22.). The pair wise comparison between treatments mean was statistically significant (*p* < 0.05) in T10 and T9 (Table 7.5.).

**Number of grain rows per cob**

The mine spoils had averaged number of grains rows per cob of 7.68, however on replacement of mine spoiled soil by top soil of community protected forest (T10) the number of grain rows per cob increased significantly by 20.05%. We also observed an increased by (16.67 to 7.03%) in the number of grain rows per cob of mine spoiled soils by other management interventions like adopting inorganic fertilizers (NPK @100 RDF) (T9) and 50% RDF + *F. mosseae* (T5) over T0 (Figure 7.23.). The pair wise comparison between treatments mean was statistically significant (*p* < 0.05) in T10 and T9 (Table 7.6.).

**Number of grains per row**

The mine spoils had averaged number of grains per row of 5.74, however on replacement of mine spoiled soil by top soil of community protected forest (T10) the number of grain per row increased significantly by 35.01%. We also observed increased by (29.61 to 9.93%) in the number of grains per row of mine spoiled soils by other management interventions like adopting inorganic fertilizers (NPK @100 RDF) (T9) and 50% RDF + *F. mosseae* + *R. intraradices* + *S. constrictum* (T8), over T0 (Figure 7.24.). The pair wise comparison between treatments mean was statistically significant (*p* < 0.05) in T10 and T9 (Table 7.6.).

**Number of grains per cob**

In maize cowpea intercropping condition (T0) the mine spoils had averaged number of grains per cob of 44.07, however on replacement of mine spoiled soil by top soil of community protected forest (T10) the number of grains per cob increased significantly by 62.12%. We also observed an increased by (51.32 to 17.15%) in the number of grains per cob of mine spoiled soils by other management interventions like adopting inorganic fertilizers (NPK @100 RDF) (T9) and 50% RDF + *F. mosseae* + *R. intraradices* + *S. constrictum* (T8), over T0 (Figure 7.25.). The pair wise comparison between treatments mean for number of grains per cob was statistically significant (*p* < 0.05) in T10 and T9 (Table 7.6.).

**Grain yield per plant**

The mine spoils had averaged grain yield per plant of 16.09 g, however on replacement of mine spoiled soil by top soil of community protected forest (T10) the grain yield increased significantly by 64.13%. We also observed increased by (57.73 to 13.79%) in grain yield per plant in mine spoiled soils by other management interventions like adopting inorganic fertilizers (NPK @100 RDF) (T9) and 50% RDF + *F. mosseae* + *R. intraradices* + *S. constrictum* (T8) over T0 (Figure 7.26.). The pair wise comparison between treatments mean was statistically significant (*p* < 0.05) in T10, T9 and T8 (Table 7.6.).

**Test weight**

The mine spoils had averaged test weight of 187.53 g, however on replacement of mine spoiled soil by top soil of community protected forest (T10) the test weight increased significantly by 19.44%. We also observed an increased by (16.81 to 6.88%) in test weight of maize in mine spoiled soils by other management interventions like adopting inorganic fertilizers (NPK @100 RDF) (T9) and 50% RDF + *F. mosseae* + *R. intraradices* + *S. constrictum* (T8) over T0 (Figure 7.27.).The pair wise comparison between treatments mean was statistically significant (*p* < 0.05) in T10, T9 and T8 (Table 7.6.).

**Grain yield**

The mine spoils had averaged grain yield of 0.30 t ha-1, however on replacement of mine spoiled soil by top soil of community protected forest (T10) the grain yield increased significantly by 1.58%. We also observed increased (1.43 to 0.11%) in grain yield of mine spoiled soils by other management interventions like adopting inorganic fertilizers (NPK @100 RDF) (T9) and 50% RDF + *F. mosseae* + *R. intraradices* + *S. constrictum* (T8) over T0 (Figure 7.28.). The pair wise comparison between treatments mean was statistically significant (*p* < 0.05) in T10, T9 and T8 (Table 7.6.).

**Stover yield**

The mine spoils had averaged stover yield of 0.47 t ha-1, however on replacement of mine spoiled soil by top soil of community protected forest (T10) the stover yield increased significantly by 2.37%. We also observed increased by (2.21 to 0.27%) change in stover yield of mine spoiled soils by other management interventions like adopting inorganic fertilizers (NPK @100 RDF) (T9) and 50% RDF + *F. mosseae* + *R. intraradices* + *S. constrictum* (T8) over T0 (Figure 7.29.). The pair wise comparison between treatments mean was statistically significant (*p* < 0.05) in T10, T9 and T8 (Table 7.6.).

**Biological yield**

The mine spoils had averaged biological yield of 0.77 t ha-1, however on replacement of mine spoiled soil by top soil of community protected forest (T10) the biological yield increased significantly by 3.95%. We also observed increased by (3.64 to 0.38%) change in biological yield of mine spoiled soils by other management interventions like adopting inorganic fertilizers (NPK @100 RDF) (T9) and 50% RDF + *F. mosseae* + *R. intraradices* + *S. constrictum* (T8) over T0 (Figure 7.30.). The pair wise comparison between treatments mean for biological yield was statistically significant (*p* < 0.05) in T10, T9 and T8 (Table 7.6.).

**Harvest Index**

The mine spoils had averaged harvest index of 0.35, however on replacement of mine spoiled soil by top soil of community protected forest (T10) the harvest index increased significantly by 0.05% followed by We also observed increased by (0.04 to 0.01%) change in harvest index of mine spoiled soils by other management interventions like adopting inorganic fertilizers (NPK @100 RDF) (T9) and 50% RDF + *F. mosseae* + *R. intraradices* + *S. constrictum* (T8) over T0 (Figure 7.31.). The pair wise comparison between treatments mean for harvest index was statistically significant (*p* < 0.05) in T10 and T9 (Table 7.6.).

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| Fig. | |

**Table Analysis of variance (ANOVA) on the effect of maize-cowpea intercropping system on plant growth parameters and yield studies under different treatments**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treatments** | **Plant Height**  **(cm)** | **Dry matter production**  **(g plant-1)** | **No. of cobs per plant** | **Cob length (cm)** | **Cob diameter (cm)** |
| To | 112.24±0.75a | 113.50±0.79a | 0.74±0.03a | 7.79±0.24a | 4.46±0.17a |
| T1 | 135.50±0.58c | 152.17±0.63b | 0.83±0.03ab | 8.45±0.13b | 5.90±0.23b |
| T2 | 135.15±1.28c | 151.81±0.77b | 0.81±0.02ab | 8.61±0.16bc | 5.91±0.36b |
| T3 | 131.75±0.85b | 153.77±0.69bc | 0.80±0.02ab | 8.70±0.25bc | 6.01±0.26b |
| T4 | 132.25±0.85b | 155.03±0.66c | 0.91±0.01ab | 8.60±0.44bc | 6.19±0.27b |
| T5 | 141.92±0.70d | 165.46±0.77ef | 1.07±0.01b | 9.24±0.26cd | 7.32±0.18cd |
| T6 | 142.36±0.61d | 163.86±0.62de | 1.02±0.01ab | 9.31±0.17cd | 7.06±0.21c |
| T7 | 142.39±1.19d | 162.35±1.21d | 1.06±0.01b | 9.25±0.13cd | 7.10±0.56c |
| T8 | 141.31±0.49d | 167.34±0.76f | 2.31±0.19c | 9.28±0.24d | 7.24±0.09d |
| T9 | 146.63±0.46e | 192.48±0.71g | 2.41±0.15e | 9.89±0.09e | 7.44±0.30e |
| T10 | 149.29±0.30f | 202.86±0.82h | 2.38±0.16d | 10.77±0.12f | 7.57±0.16f |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treatments** | **No of grain rows per cob** | **No of grains per row** | **No. of grains per cob** | **Grain yield per plant (g)** | **Test weight (g)** |
| To | 7.68±0.11a | 5.74±0.06a | 44.07±0.69a | 16.09±0.23a | 187.53±0.82a |
| T1 | 8.38±0.14b | 6.30±0.10b | 52.79±1.23b | 18.74±0.40ab | 200.45±0.63b |
| T2 | 8.26±0.17b | 6.31±0.12b | 52.14±1.48b | 18.47±0.20ab | 201.55±0.73bc |
| T3 | 8.22±0.04b | 6.28±0.09b | 51.63±0.82b | 18.31±0.15ab | 201.41±0.94bc |
| T4 | 8.30±0.29b | 6.31±0.11b | 52.42±2.57b | 19.68±0.37ab | 202.75±0.45c |
| T5 | 8.80±0.13bcd | 7.04±0.21c | 61.98±2.67cd | 23.94±0.58b | 211.24±0.88d |
| T6 | 8.58±0.21bc | 7.02±0.12c | 60.22±1.75c | 22.98±0.52b | 211.10±0.57d |
| T7 | 8.51±0.20bc | 7.05±0.11cd | 59.94±1.53c | 23.42±0.41b | 211.58±0.77d |
| T8 | 8.64±0.09bc | 7.40±0.25d | 63.87±2.23d | 31.75±3.62c | 213.98±0.55e |
| T9 | 8.96±0.04e | 7.44±0.22e | 66.69±2.11e | 35.38±3.45d | 219.06±0.49f |
| T10 | 9.22±0.30f | 7.75±0.14f | 71.45±3.02f | 38.41±4.20e | 223.99±0.58g |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Treatments** | **Grain yield**  **(t ha-1)** | **Stover yield (t ha-1)** | **Biological yield (t ha-1)** | **Harvest Index** | **AMF Spores**  **(100 g soil)** | **Root Infection**  **(%)** |
| To | 0.30±0.01a | 0.47±0.02a | 0.77±0.03a | 0.35±0.002a | 220.75±2.17a | 60.59±1.32a |
| T1 | 0.43±0.02ab | 0.78±0.04ab | 1.21±0.06ab | 0.36±0.002a | 243.75±2.32b | 73.25±1.89c |
| T2 | 0.42±0.01ab | 0.75±0.02ab | 1.16±0.03ab | 0.36±0.002a | 252.50±2.96c | 69.88±0.82b |
| T3 | 0.41±0.01ab | 0.74±0.02ab | 1.15±0.03ab | 0.36±0.002a | 241.50±2.63b | 72.50±1.27bc |
| sT4 | 0.47±0.02ab | 0.81±0.03ab | 1.28±0.05ab | 0.37±0.002ab | 268.40±1.75e | 85.50±1.88e |
| T5 | 0.68±0.03b | 1.13±0.06b | 1.81±0.08b | 0.38±0.002b | 260.75±3.47d | 81.00±1.75d |
| T6 | 0.64±0.03b | 1.03±0.06b | 1.67±0.08b | 0.38±0.003b | 265.40±2.84e | 84.25±2.39e |
| T7 | 0.66±0.02b | 1.06±0.05b | 1.72±0.07b | 0.38±0.004b | 260.70±2.87d | 83.00±1.39e |
| T8 | 1.56±0.18c | 2.46±0.29c | 4.01±0.46c | 0.39±0.002ab | 257.75±3.35cd | 80.75±1.76d |
| T9 | 1.73±0.17d | 2.68±0.27d | 4.41±0.44d | 0.39±0.002c | 250.50±2.60c | 78.23±0.79cd |
| T10 | 1.88±0.21e | 2.84±0.29e | 4.72±0.50e | 0.40±0.002d | 310.75±3.07f | 90.75±1.75f |

Values are mean for four replicates ± standard error mean; within a column values that differed significantly are followed by different letters as determined by One-way ANOVA incorporating Duncan’s Multiple Range Test (DMRT at *p* < 0.05) for pair-wise comparison between means. \*Significant at *p* < 0.05, ns: Non-significant at *p* > 0.05

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| --- | --- |
| F:\FRI-Final Submission\Plates\New folder\IMG_20190604_132018.jpg  **Plate 7.3.** (a-d) Luxuriant growth of maize plants through management interventions in limestone mine spoils | F:\FRI-Final Submission\Plates\New folder\IMG_20190604_132049.jpg |
| F:\AMF Photographs-final\Gary Suting (Colonization Pictures)\Treatments\Maize\T9-M-Ar-006.jpg  **Plate 7.5.** (a-f) AMF root colonization in maize (*Zea mays* L.) under different treatments (b) Arbuscles colonization in50% RDF + *F. mosseae* + *R. intraradices* + *S. constrictum* treatment (T8) (f) Hyphae colonization in control, no inputs (T0) **Scale bars:** a- f = 50µm  **Scale bars:** a- f = 50µm | F:\AMF Photographs-final\Gary Suting (Colonization Pictures)\Treatments\Maize\T10-M-Hy-009.jpg |
| F:\FRI-Final Submission\Plates\IMG_20190718_144400.jpgF:\FRI-Final Submission\Plates\IMG_20190718_144152.jpgF:\FRI-Final Submission\Plates\IMG_20190718_144305.jpgF:\FRI-Final Submission\Plates\IMG_20190718_144011.jpgF:\FRI-Final Submission\Plates\IMG_20190718_143632.jpgF:\FRI-Final Submission\Plates\IMG_20190718_143856.jpg  **Plate 7.4.** (a-d)Harvested maize cobs under different treatment combinations **(a)** *F. mosseae* inoculum (T1), *R. intraradices* inoculum (T2) **(b)** *S. constrictum* inoculum (T3), *F. mosseae* + *R. intraradices*+ *S. constrictum* consortia (T4) **(c)** 50% RDF + *F. mosseae* (T5), 50% RDF + *R. intraradices* (T6) **(d)** 50% RDF + *S. constrictum* (T7), 50% RDF + *F. mosseae* + *R. intraradices* + *S. constrictum* consortia (T8) **(e)** NPK @100 RDF (T9), Top soil from community protected forest (T10) and **(f)** Control (no inputs) | |

**Conclusion**

It was observed and experimentally tested that replacement of mined spoiled soil by top soil from adjacent un-mined community protected forest followed by addition of inorganic fertilizers (NPK@100 RDF) and adoption of 50 % RDF + *F. mosseae* + *R. intraradices* + *S. constrictum* were found to be the most suitable management interventions for rehabilitation and rejuvenation of the fragile mining ecosystem. The reclamation strategy can be applied for the successful restoration of limestone mine for faster recovery of plant species diversity and microbial populations.

**Acknowledgement**

**References**

1. Banerjee, S. K., Williams, A.J., Biswas, S.C., Manjhi, R.B. and Mishra, T.K. (1996). Dynamics of natural eco-restoration in coal mine overburden of dry deciduous zone of M.P. India. *Ecology, Environment and Conservation*, 2: 97-104.