# Response of Conservation Measures on the Growth of Planted Species and Improvement in Soil Properties in a Degraded Area

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## 1 Introduction

None of the natural resource is so valuable as land. This forms the base of all human activities, hence has been subjected to maximum exploitation, be it for production, construction or otherwise. Singh *et al*. (1992) made an attempt to select suitable tree species for skeletal soil of Sambalpur (Orissa, India) by carrying out plantation with some selected species and assessing their relative performance. Moisture and thermal stress in eroded skeletal soil affect the availability and absorption of water and nutrients by plants and consequently the establishment and growth of plants. Gupta and Aggarwal (1988) have also expressed similar view with regard to sandy wastelands of Rajasthan. Mulching has been found to be very effective in lowering soil temperature in root zone (Prihar et al. 1979) as well as conserving soil moisture and checking evaporation. Mulching also promotes growth of tree species in degraded soils (Singh and Saggar, 1997). In areas where slope is higher and run off and erosion is severe contour trenching becomes essential to arrest water and allow it to percolate in the soil for its availability to plants. Further, deficiency of phosphorus in the soils of Jabalpur is a common phenomenon. VAM fungi are known to enhance nutrient uptake, especially P from the soil (Harley and Smith, 1983). Verma and Jamaluddin (1994) have pointed out that AM fungi also enhance tolerance to drought in tree species. The present study was therefore, aimed to assess the effect of soil conservation measure (staggered trenching) in association with VAM application on growth of tree species in severely eroded land and improvement of soil properties.

## 2 Material and Methods

The present study was carried out in an area around Tropical Forest Research Institue, Jabalpur (23°5′3'7″ to 23°6′10″ N and 79°58′ 49″ to 79°59′42″ E), Madhya Pradesh, India. Two study sites were selected, of which site II was located within the Tropical Forest Research Institute campus, while the other (Site I) comprised of a small hillock having slope of 15% — 20%, located at village Pipariya khurd. The 2$^{nd}$ site was having less slope (3% — 5%) but the degree of soil erosion was almost the same at both sites. The soil was also similar but with little variation as shown in table-1. Erosion, high runoff, soil depth and available nutrients were major limitations. Erosion was severe and grazing pressure was very high at site-I, whereas at site-II, though erosion was very severe but grazing was stopped a year prior to experimentation. At site II the whole area was divided into two parts. One half was reserved for planting of *A.procera* and the other half was reserved for *A.lebbek*. The following treatments were applied in blocks of 10m×10m, replicated 3 times. The number of replications was taken only three due to shortage of space. The species selected for the study was *A.procera* and *A .lebbek*. At this site the plantation was done at 2m × 2m spacing in 45 cm$^3$ pits and staggered trenches (3m×0.5m×0.5m) were dug in alternate rows of plants except in blocks in which it was not prescribed as per design of the experiment. The experiment was conducted in Randomized Block Design. VAM (mixed Glomus spps.)/*Rhizobium* or VAM (mixed Glomus spps.) + *Rhizobium* in appropriate amount as shown below was mixed with the pit soil at the time of planting. Plantation was done during July 1992.

T0 — Control (No staggered trenches, no biofertilizers)
T1 — Staggered trenches only
T2 — Staggered trenches + 20 g Rhizobium/plant

T3 — Staggered trenches + 20 g VAM (mixed Glomus spps.)/plant

T4 — Staggered trenches + 20 g Rhizobium + 20 g VAM (mixed Glomus spps.)

The whole area at site I was divided into two equal parts along the central contour line forming the upper and the lower half sloppy portions. Both halves were further subdivided into sixteen equal blocks. Each half consisted of the following treatments, replicated four times:

T0 — Control (no VAM, no staggered contour trenches).

T1 — 20 g VAM(mixed Glomus spps.) per plant, no trenches.

T2 — No VAM (mixed Glomus spps.) only staggered trenches.

T3 — 20g VAM (mixed Glomus spps.) + Staggered trenches.

Plantation pits (45 $cm^3$) were dug at 2m×2m interval in the entire field. Staggered trenches of 3m× 0.5m×0.5 m were dug in all plots in alternate rows of plants, except where there was no prescription. VAM culture (20g/plant with infective propagules between 50—100) was mixed with the pit soil during plantation.

Height and girth of plants at both sites were recorded after 4.5 years of planting. Soil samples of surface horizons were also collected simultaneously and were analyzed for their physico-chemical properties as per standard procedures (Black, 1965).

**Table 1 Physico-chemical properties of soils at site I & II**

| Properties | Site II | Site I |
|---|---|---|
| Soil depth | 10 — 12 cm | 15 — 25 cm |
| pH | 6.65 — 6.80 | 6.68 — 6.88 |
| Organic matter (%) | 0.23 — 0.33 | 1.12 — 1.48 |
| Texture | Loam | Loam |
| Maximum Water Holding Capacity (MWHC %) | 40.00 — 52.30 | 45.00 — 55.20 |
| Available N ($kg \cdot ha^{-1}$) | 180.0 — 204.5 | 212.7 — 235.6 |
| Available $P_2O_5$ ($kg \cdot ha^{-1}$) | 4.46 — 4.58 | 4.76 — 8.75 |
| Available $K_2O$ ($kg \cdot ha^{-1}$) | 150 — 162 | 156.5 — 210.7 |

## 3 Results and discussion

Physico-chemical properties of the soils (Table 1) indicated that in spite of shallow depth other properties like soil texture, pH etc. were not adverse to growth of plants. However, organic matter and available nutrient status of the soils (low status of nitrogen and phosphorus and medium status of potash) as well as soil depth were the major limiting factors for growth of tree species. Since, before planting the area was open and continuously grazed, the surface soil became compact and runoff was very high. Presence of morrum and hard rock at shallow depth did not allow rainwater to percolate as such, the soil used to become very dry and desiccating during summer. Staggered trenches were dug in both the fields which were to be planted with *A. procera* and *A. lebbek* to check further soil erosion and accumulate rain water to supply it to the growing plants planted on the lower side of the trenches. Compost (2 kg/plant) was added to the pit soil to provide initial nutrient support to the plants and make the soil conducive to root development.

Figures within the parenthesis indicate percent increase over control.

Effect of above treatments (Table 2) on growth of *A. lebbek* during the same period (4.5 years) was somewhat different to that of *A. procera.* Control exhibited the least survival (30.55%) while survival in other treatments ranged between 55.55 ($T_2$) and 67.58 % ($T_4$). The percent increase in different treatments ranged between 81.83 and 121.21 % over control. Further, survival of VAM treated plants (60.18%) was slightly higher than *Rhizobium* treated plants (55.55%), though the difference between the two was non significant. This shows slight superiority of VAM over *Rhizobium*. VAM + *Rhizobium* gave the best result with significantly higher value ($P<0.05$) than *Rhizobium* alone. However, height of plants exhibited higher value in *Rhizobium* and VAM + *Rhizobium* treated plants as compared to VAM alone treated plants but the differences between VAM and *Rhizobium* as well as *Rhizobium* and *Rhizobium* + VAM treated plants were non-significant (Table 3). The table evidently shows significant (P<0.05) increase in height due to VAM + *Rhizobium* application as compared to VAM alone. On the whole, there were 14.91 ($T_1$) to 30.30 % ($T_4$) increase in height over control due to various treatments. Biological nitrogen fixation due to application of *Rhizobium* gave slightly better results in *Rhizobium* treated plants. Collar girth of species (*A. lebbek*) also exhibited almost similar trend with variations from 10.17 cm in control to 16.63cm in *Rhizobium* + VAM. Resulting increase due to application of different treatments ranged from 35.39% in trenching alone to 51.13 % in *Rhizobium* and 63.52 % in *Rhizobium* + VAM treated plants. All the treatments differed significantly with each other ($P < 0.05$).

**Table 2 Effect of staggered trenching and application of rhizobium and VAM on growth of *A. procera and A.lebbek* on severely eroded land(Site II)( age – 4.5 years)**

| Treatments | Survival (%) | Mean height (m) | Mean collar girth (cm) |
|---|---|---|---|
| *A. procera* | | | |
| T0 — Control (No trenches, no biofertilizer | 58.32 | 3.01 | 13.84 |
| T1 — Staggered trenches only | 86.64 (48.55) | 3.55 (17.94) | 17.32 (25.14) |
| T2 — Staggered trenches + Rhizobium 20 g/plant | 91.66 (57.30) | 3.69 (22.59) | 18.61 (34.46) |
| T3 — Staggered trenches + VAM 20 g/plant | 90.74 (55.59) | 3.58 (18.93) | 17.38 (25.57) |
| T4 — Staggered trenches + VAM 20 g/plant + Rhizobium 20 g/plant | 93.51 (60.34) | 3.88 (28.90) | 18.76 (35.54) |
| *A. lebbek* | | | |
| T0 — Control (No trenches, no Biofertilizer | 30.55 | 2.95 | 10.17 |
| T1 — Staggered trenches only | 60.00 (96.40) | 3.39 (14.91) | 13.77 (35.39) |
| T2 — Staggered trenches + Rhizobium 20 g/plant | 55.55 (81.83) | 3.65 (23.73) | 15.37 (51.13) |
| T3 — Staggered trenches + VAM 20 g/plant | 60.18 (96.98) | 3.50 (18.64) | 13.92 (36.87) |
| T4 — Staggered trenches + VAM 20 g/plant + Rhizobium 20 g/plant | 67.58 (121.21) | 3.85 (30.30) | 16.63 (63.52) |

Comparative study of the growth performance of the two species (*A. procera* and *A. lebbek*) exhibited increased survival of *A. procera* as compared to *A. lebbek*, while height of the plants were almost similar in both species under different treatments. Further, increase in survival over control was more in *A. lebbek* than *A. procera* particularly in the plants treated with VAM. This indicated that the effect of VAM on survival of plants is more in *A. lebbek* than *A. procera*. Effect of *Rhizobium* seems to be almost similar in both the species as is also evident from the collar girth of both the species. However, the value is somewhat lower in *A. lebbek* than *A. procera*. This indicted that effect of *Rhizobium* on biological nitrogen fixation was similar in both the species.

Thus, it can be concluded that for rehabilitating such type of severely eroded soil, where soil depth and nutrients are the limiting factors, pits of 45 $cm^3$ should be dug along with staggered trenches. Compost at least 2 kg/pit should be added to the soil to provide initial nutrient support and *Rhizobium* +

VAM should be mixed with the pit soil to increase microbial activities to obtain better survival and growth of nitrogen fixing tree species like *A. procera* and *A. lebbek.*

**Table 3 Correlation coefficient values (r) between different parameters of study**

*A. procera*

| | S | H | CG | pH | OM | MWHC | N | P | K |
|---|---|---|---|---|---|---|---|---|---|
| S | 1.000 | | | | | | | | |
| H | 0.961** | 1.000 | | | | | | | |
| Cg | 0.974** | 0.983** | 1.000 | | | | | | |
| pH | –0.850* | –0.836* | –0.770 | 1.000 | | | | | |
| OM | 0.629 | 0.812* | 0.716 | –0.687 | 1.000 | | | | |
| MWHC | 0.725 | 0.861* | 0.838* | –0.620 | 0.901* | 1.000 | | | |
| N | 0.787 | 0.925** | 0.859* | –0.756 | 0.971** | 0.929** | 1.000 | | |
| P | 0.918** | 0.987** | 0.962** | –0.737 | 0.810* | 0.836* | 0.923** | 1.000 | |
| K | 0.829* | 0.940** | 0.917** | –0.706 | 0.907* | 0.981** | 0.965** | 0.925** | 1.000 |

*A. lebbek*

| | S | H | CG | pH | OM | MWHC | N | P | K |
|---|---|---|---|---|---|---|---|---|---|
| S | 1.000 | | | | | | | | |
| H | 0.905* | 1.000 | | | | | | | |
| Cg | 0.913** | 0.995** | 1.000 | | | | | | |
| pH | –0.928* | –0.987** | –0.974** | 1.000 | | | | | |
| OM | 0.877* | 0.970** | 0.966** | 0.960** | 1.000 | | | | |
| MWHC | 0.842* | 0.961** | 0.958** | 0.941** | 0.997** | 1.000 | | | |
| N | 0.765 | 0.740 | 0.717 | 0.794 | 0.854* | 0.836* | 1.000 | | |
| P | 0.972** | 0.928** | 0.941** | 0.937** | 0.856* | 0.826* | 0.627 | 1.000 | |
| K | 0.955** | 0.890* | 0.888* | 0.928** | 0.929** | 0.903* | 0.917** | 0.877* | 1.000 |

S = Survival %, H = Height, CG = Collar girth, OM= Organic matter %,
MWHC = Maximum water holding capacity %, N= Available nitrogen,
P= Available $P_2O_5$, K= Available $K_2O$
* Significant at 5 %, ** Significant at 1%

Development of better moisture regime in root zone due to staggered trenching probably increased the proliferation and activity of VAM leading to higher water and nutrient uptake (Bougher *et al.*, 1990; Duddridge *et al.*, 1980; Hayman, 1983) and consequent growth of plants. Staggered trenches have added to the moisture content of the soil through checking runoff and consequent increase in litter decomposition rate. Encouraged with the findings this experiment an experiment was conducted using non-nitrogen fixing tree species as a test species.

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