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# Effect of *Pongamia pinnata* Seed Source on Litter Quality and Decomposition Under Agroforestry System

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## ABSTRACT

A field investigation 'Effect of *Pongamia pinnata* seed source on litter quality and decomposition under agroforestry system' was conducted at the University of Agricultural Sciences, Dharwad, Karnataka, India. To find suitable seed sources for inclusion in agroforestry conditions, eleven Pongamia pinnata seed sources from three provenances - Maharashtra, Tamil Nadu, and Karnataka were selected. When nitrogen concentration (%) was measured at 12 MAI, the treatment RAK-89 (2.35%) had the highest values at the surface, followed by RAK-05 (2.09%), and the treatment RAK-106 (1.46%). The treatment RAK-22 had greater potassium concentrations of 0.64, 0.60, 0.31, and 0.17 at 3 MAI (Month After Inception), 6 MAI, 9 MAI, and 12 MAI, respectively, while DPS-4 had lower potassium concentrations of 0.28, 0.26, 0.14, and 0 at 3, 6, and 9 MAI, respectively. Higher lignin percentages were obtained at surface placement for the treatment MTP-I with values of 35.8, 29.7, 25.7, and 21.2 at 3, 6, 9, and 12 MAI, whereas a similar trend was observed at subsurface placement with values of 33.3, 27.9, 23.9, and 20.9 per cent for 3, 6, 9, and 12 MAI. There was also variation in the cellulose, ash, and phosphorus levels of the *Pongamia pinnata* sources.

*Keywords* : *Pongamia pinnata* source, Lignin, NPK, Ash, Cellulose

THE medium-sized, evergreen *Pongamia pinnata* tree belongs to the Papilionace family and has a broad crown and a short bole. It is one of the few trees that fix nitrogen while producing seeds with 30-40 per cent oil. The Asian subcontinent's beaches and riverbanks are where they naturally occur. Additionally, it is planted in open fields and along the banks of canals and roadways. It is suggested for preventing soil erosion and stabilizing sand dunes because of its extensive network of lateral roots. It has long been utilized as a medicinal plant because of the medicinal qualities of its root, bark, leaves, sap, and flowers.

The seeds are mostly used to produce 'Karanja oil,' a non-edible oil with well-known therapeutic benefits that is sold commercially. 95 per cent of the Pongamia seed is the kernel, and the remaining 25 to 40 per cent is oil.

Numerous studies have shown both the positive and negative effects of trees on the crops grown in their shade. With increasing tree size and stand density, the effects are more noticeable (Harsh and Tewari, 1993). Depending on the species and planting pattern, trees have an impact on the soil and the ecosystem around them. These environmental changes affect agricultural productivity (Chauhan, 2000).

## MATERIAL AND METHODS

The experiment was conducted in the 'I' block of the agroforestry experimental field at the Main Agricultural Research Station (MARS), University of Agricultural Sciences, Dharwad, during the 2013-2014 *rabi* season. In a continuing agroforestry project, 11 *Pongamia pinnata* seed sources were planted in 2006 at a spacing of 6 m by 4 m. One in Karnataka (DPS-4) and seven in Maharashtra

(RAK-103, RAK-106, RAK-11, RAK-90, RAK-22, RAK-05 and RAK-89) are sources of *Pongamia* seeds, respectively (RAK-Rahuri Karanj, MTP-Mettupalyam and DPS-Dharwad Pongemia sources).

**Decomposition Rate under Field Conditions and Nutrient Changes during Decomposition**

For this study, 11 different *Pongamia pinnata* seed sources were chosen. To make it easier for microarthropods to move around, nylon netting bags of 25 cm × 25 cm with a mesh size of 1 mm were used to study decomposition. The oven-dried leaf weighed 20 g in each bag since there was simply excessive material to dry it by air. There were two sets of these bags prepared. In March 2013, one pair was at random placed on the cultivated field's surface and the other was placed in the subsurface or plough layer. For a year, every three months, trash bags from each lot were selected and taken to the lab for analysis. After carefully separating the recovered material from the soil particles, it was dried to a consistent weight at 60 °C. On the initial day of placement (May 31), as well as at subsequent monthly intervals, dry weight observations were made.

The remaining litter's nitrogen, phosphorous, potassium and magnesium content was calculated for each sampling date. The recovered material was sequentially cleaned using tap water, 0.1N HCL and distilled water at each interval. The washed samples were first allowed to air dry before being dried in the oven for 48 hours at 60.5°C.

To determine total nitrogen, a 0.5 g plant sample was digested in concentrated $H_2SO_4$ using a digestion mixture. After digestion, N was calculated using the Kjeltec Auto 1030 Analyzer. Analysing samples in a 4:1 nitro-perchloric acid solution allowed researchers to identify the concentrations of phosphorus, potassium, calcium and magnesium. Using the Vanado-molybdo-phosphoric yellow color procedure and the Spectromic 20-D, the amount of phosphorus in the absorb was determined. Calcium, magnesium, and potassium were measured using an atomic absorption spectrometer.

**Nutrient Retention**

The total nitrogen, phosphorus, potassium, and magnesium released from the leaf litter were calculated using the formula below.

$$\text{Per cent absolute nutrient remaining} = \frac{C}{C_o} \times \frac{DM}{DM_o} \times 100$$

Where,

$C_o$ = Original concentration of the element in leaf litter

C = Concentration after a given period

$DM_o$ = Original mass of dry matter

DM = Mass of dry matter after a given period

**Substrate Quality and Nutrient Uptake by *Pongamia pinnata***

Initial leaf samples were examined for lignin, ash and cellulose content following Gupta *et al.* (1988) instructions to assess the substrate quality. The cumulative weight loss was then correlated with these factors and the coefficient of correlation between the above-mentioned quality measures and cumulative weight loss was calculated.

After being oven-dried and ground in a Willy mill, plant samples obtained during final observations were used to estimate the levels of nitrogen, phosphorus, and potassium. The amount of N, P and K that trees absorb was calculated based on the nutrient profile of plants and dry weight per plant. Yoshida *et al.* (1971) modified the Kjeldahl method to estimate nitrogen content in plants and Jackson (1973) followed it to estimate phosphorus and potassium content.

## Results and Discussion

The dynamics of nitrogen, phosphorus, lignin, cellulose, ash, nitrogen and potassium in the leaf litter of 11 seed sources of *Pongamia pinnata* that were chosen after a three-month repetition interval constitute a basis for the findings.

TABLE 1

Initial chemical composition (%) of the naturally shaded leaf material of different seed sources of *Pongamia pinnata*

| Seed sources | N | P | K | C | C:N | Mg | Lignin | Cellulose | Ash |
|---|---|---|---|---|---|---|---|---|---|
| $T_1$-RAK-103 | 2.18 | 0.48 | 0.30 | 44.8 | 20.5 | 1.89 | 22.5 | 27.1 | 10.2 |
| $T_2$-RAK-106 | 2.04 | 0.81 | 0.39 | 43.3 | 21.2 | 0.98 | 25.9 | 31.2 | 18.2 |
| $T_3$-RAK-11 | 2.43 | 0.48 | 0.42 | 43.9 | 18.1 | 2.02 | 28.5 | 26.8 | 10.2 |
| $T_4$-RAK-90 | 2.26 | 0.84 | 0.62 | 34.3 | 15.2 | 2.95 | 34.9 | 25.6 | 25.1 |
| $T_5$-RAK-22 | 2.29 | 0.71 | 0.65 | 35.5 | 15.5 | 2.45 | 31.5 | 24.3 | 23.2 |
| $T_6$- RAK-05 | 2.62 | 0.49 | 0.29 | 41.5 | 15.8 | 1.59 | 26.8 | 26.0 | 11.5 |
| $T_7$-RAK-89 | 2.92 | 0.59 | 0.52 | 40.6 | 13.9 | 1.64 | 32.3 | 24.8 | 2.8 |
| $T_8$-MTP-I | 1.86 | 0.51 | 0.51 | 46.3 | 24.8 | 0.96 | 39.4 | 33.7 | 3.8 |
| $T_9$-MTP-II | 1.88 | 0.43 | 0.32 | 42.2 | 22.5 | 1.82 | 37.7 | 30.8 | 4.0 |
| $T_{10}$-MTP-III | 1.98 | 0.62 | 0.32 | 42.8 | 21.6 | 0.92 | 34.1 | 31.5 | 9.2 |
| $T_{11}$-DPS-4 | 2.10 | 0.59 | 0.29 | 46.9 | 22.3 | 1.24 | 27.7 | 27.3 | 10.4 |
| Mean | 2.23 | 0.6 | 0.42 | 42.01 | 19.22 | 1.68 | 29.85 | 28.1 | 11.69 |

### Changes in Nitrogen Concentration in Decomposing Litter

The data on changes in nitrogen levels in decomposing litter revealed significant diversity across various Pongamia sources, incubation levels, and interactions between Pongamia sources at all stages of the experiment, as shown in Table 2. All Pongamia source's surface placement decomposing litter nitrogen concentration became during the first six months, after which it started to decline and eventually reached its lowest concentration. Additionally, a trend resembling surface placement was seen in the subsurface location, but the actual values were slightly lower. At 3 MAI, the seed source RAK-89 (2.91%) had the highest nitrogen concentration, followed by RAK-05 (2.59%). At 6 MAI, the seed source RAK-89 (2.98%) had the highest nitrogen concentration, followed by RAK-05 (2.72%). At subsurface placement, a similar tendency was seen, but with slightly higher values than 3 MAI. Significant changes were between incubation levels, and there was a significant interaction between incubation level and seed source. Except for the treatment DPS-4 seed source under subsurface soil placement, where the litter disintegrated, a similar trend was seen for different seed sources and incubation levels at 9 MAI with changes in nitrogen concentration (%). At 12 MAI, nitrogen concentration (%) was noted with greater values at surface placement for seed source RAK-89 (2.35%), RAK-05 (2.09%) and least observed in the treatment RAK-106 (1.46%), but the treatment DPS-4 was degraded. The seed sources RAK-106, RAK-103, RAK-05, RAK-11 and DPS-4 vanished at the subsurface planting.

### Changes in Phosphorus Concentration in Decomposing Litter

Contrary to nitrogen, phosphorus concentration dramatically reduced over the first six months (6 MAI), but gradually increased throughout that period (9 MAI) (Table 3). Higher significant variance was seen between seed sources and incubation level at all stages, however at 3 MAI and 6 MAI, respectively, the interaction effect between seed sources and incubation level revealed non-significant variation. At 3 MAI, the treatment RAK-90 had the highest concentration of phosphorus at the surface, followed by RAK-106 (0.78%) and the treatment MTP-II (0.40%). A similar pattern with declining values was seen for subsurface placement. The impact

TABLE 2

Changes in nitrogen concentration (%) in decomposing leaf litter of *Pongemia pinnata* at various intervals

| Seed source | 3 MAI | | 6 MAI | | 9 MAI | | 12 MAI | |
|---|---|---|---|---|---|---|---|---|
| | Surface | SubSurface | Surface | SubSurface | Surface | SubSurface | Surface | SubSurface |
| $T_1$ -RAK-103 | 2.14 | 2.12 | 2.20 | 2.18 | 2.19 | 2.16 | 1.79 | - |
| $T_2$ -RAK-106 | 1.98 | 1.91 | 2.10 | 2.05 | 2.08 | 2.07 | 1.46 | - |
| $T_3$ -RAK-11 | 2.36 | 2.30 | 2.46 | 2.37 | 2.45 | 2.43 | 1.97 | - |
| $T_4$ -RAK-90 | 2.16 | 2.15 | 2.21 | 2.17 | 2.20 | 2.15 | 1.71 | 1.65 |
| $T_5$ -RAK-22 | 2.25 | 2.19 | 2.31 | 2.28 | 2.29 | 2.25 | 1.89 | 1.71 |
| $T_6$ - RAK-05 | 2.59 | 2.58 | 2.72 | 2.68 | 2.70 | 2.65 | 2.09 | - |
| $T_7$ -RAK-89 | 2.91 | 2.90 | 2.98 | 2.92 | 2.96 | 2.89 | 2.35 | 2.29 |
| $T_8$ -MTP-I | 1.79 | 1.76 | 1.83 | 1.78 | 1.82 | 1.77 | 1.47 | 1.42 |
| $T_9$ -MTP-II | 1.82 | 1.80 | 1.88 | 1.85 | 1.87 | 1.84 | 1.56 | 1.51 |
| $T_{10}$ -MTP-III | 1.95 | 1.89 | 2.05 | 2.03 | 2.03 | 1.99 | 1.65 | 1.56 |
| $T_{11}$ -DPS-4 | 2.05 | 2.01 | 2.14 | 2.09 | 2.12 | - | - | - |
| For comparing means of | SEm ± | CD (0.05) | SEm ± | CD (0.05) | SEm ± | CD (0.05) | SEm ± | CD (0.05) |
| Seed source (T) | 0.010 | 0.030 | 0.010 | 0.027 | 0.010 | 0.030 | 0.002 | 0.006 |
| Incubation level (I) | 0.004 | 0.013 | 0.004 | 0.012 | 0.004 | 0.013 | 0.001 | 0.002 |
| Interaction (T × I) | 0.015 | 0.042 | 0.014 | 0.039 | 0.015 | 0.042 | 0.003 | 0.008 |

TABLE 3

Changes in Phosphorous concentration (%) in decomposing leaf litter of *Pongemia pinnata* at various intervals

| Seed source | 3 MAI | | 6 MAI | | 9 MAI | | 12 MAI | |
|---|---|---|---|---|---|---|---|---|
| | Surface | SubSurface | Surface | SubSurface | Surface | SubSurface | Surface | SubSurface |
| $T_1$ -RAK-103 | 0.46 | 0.46 | 0.45 | 0.44 | 0.76 | 0.71 | 0.92 | - |
| $T_2$ -RAK-106 | 0.78 | 0.76 | 0.77 | 0.77 | 0.97 | 0.93 | 0.99 | - |
| $T_3$ -RAK-11 | 0.46 | 0.45 | 0.44 | 0.43 | 0.73 | 0.70 | 0.89 | - |
| $T_4$ -RAK-90 | 0.81 | 0.78 | 0.80 | 0.79 | 0.99 | 0.95 | 0.97 | 0.99 |
| $T_5$ -RAK-22 | 0.68 | 0.65 | 0.67 | 0.65 | 0.92 | 0.90 | 0.95 | 0.99 |
| $T_6$ - RAK-05 | 0.45 | 0.44 | 0.43 | 0.42 | 0.69 | 0.65 | 0.80 | - |
| $T_7$ -RAK-89 | 0.56 | 0.54 | 0.54 | 0.53 | 0.81 | 0.79 | 0.90 | 0.89 |
| $T_8$ -MTP-I | 0.48 | 0.45 | 0.44 | 0.42 | 0.73 | 0.69 | 0.89 | 0.87 |
| $T_9$ -MTP-II | 0.40 | 0.38 | 0.37 | 0.35 | 0.63 | 0.59 | 0.84 | 0.83 |
| $T_{10}$ -MTP-III | 0.60 | 0.59 | 0.59 | 0.57 | 0.86 | 0.82 | 0.93 | 0.96 |
| $T_{11}$ -DPS-4 | 0.56 | 0.55 | 0.56 | 0.54 | 0.79 | - | - | - |
| For comparing means of | SEm ± | CD (0.05) | SEm ± | CD (0.05) | SEm ± | CD (0.05) | SEm ± | CD (0.05) |
| Seed source (T) | 0.013 | 0.037 | 0.013 | 0.036 | 0.07 | 0.020 | 0.002 | 0.005 |
| Incubation level (I) | 0.006 | 0.016 | 0.005 | 0.016 | 0.003 | 0.008 | 0.001 | 0.002 |
| Interaction (T × I) | 0.018 | NS | 0.018 | NS | 0.010 | 0.028 | 0.003 | 0.008 |

of the contact was insignificant. At surface implantation at 6 MAI, treatment RAK-90 had the highest concentration of phosphorus (0.80%), followed by RAK-106 (0.77%) and treatment MTP-II had the lowest concentration (0.37%). At 6 MAI, there was minimal to no change in the phosphorus content at subsurface placement. Significantly higher values were discovered at 9 MAI compared to 6 MAI and the concentration of phosphorus was found to be high for RAK-90 (0.999%), followed by RAK-106 (0.97%) and lowest for MTP-II (0.63%). Significant differences were discovered in the seed sources, incubation level and their interactions. Surface and subsurface placement were found to differ considerably concerning seed sources, incubation placement and their interactions at 12 MAI, whereas litter vanished in RAK-103, RAK-106, RAK-11 and RAK-05 at subsurface placement. However, it vanished in both surface and subsurface locations in DPS-4.

**Changes in Potassium Concentration in Decomposing Litter**

As the decomposition process progressed, the potassium concentration in the decaying surface litter fell. The decline was moderate and gradual until 6 MAI. Following that, in 9 MAI, its concentration dropped precipitously, reaching a low of 0.08 per cent in 12 MAI. A similar pattern was seen in subsurface litter with a minimum value of 0.07 in 12 MAI. The RAK-22 had the highest potassium concentrations of 0.64, 0.60, 0.31 and 0.17 at 3 MAI, 6 MAI, 9 MAI, and 12 MAI seed sources, respectively, while the DPS-4 had the lowest potassium concentrations of 0.28, 0.26, 0.14 and 0 at 3, 6, 9, and 12 MAI. A similar tendency was observed with subsurface placement (Table 4).

**Changes in Lignin Concentration in Decomposing Litter**

Lignin concentration gradually dropped from 35.8 to 16.7 per cent for various Pongamia sources for surface

TABLE 4

Changes in Potassium concentration (%) in decomposing leaf litter of *Pongemia pinnata* at various intervals

| Seed source | 3 MAI | | 6 MAI | | 9 MAI | | 12 MAI | |
|---|---|---|---|---|---|---|---|---|
| | Surface | SubSurface | Surface | SubSurface | Surface | SubSurface | Surface | SubSurface |
| $T_1$-RAK-103 | 0.28 | 0.27 | 0.20 | 0.18 | 0.15 | 0.13 | 0.11 | - |
| $T_2$-RAK-106 | 0.38 | 0.37 | 0.29 | 0.25 | 0.18 | 0.14 | 0.08 | - |
| $T_3$-RAK-11 | 0.41 | 0.38 | 0.39 | 0.37 | 0.21 | 0.17 | 0.08 | - |
| $T_4$-RAK-90 | 0.60 | 0.59 | 0.59 | 0.58 | 0.27 | 0.23 | 0.13 | 0.10 |
| $T_5$-RAK-22 | 0.64 | 0.63 | 0.60 | 0.59 | 0.31 | 0.26 | 0.17 | 0.13 |
| $T_6$-RAK-05 | 0.28 | 0.27 | 0.25 | 0.24 | 0.14 | 0.12 | 0.09 | - |
| $T_7$-RAK-89 | 0.51 | 0.50 | 0.50 | 0.48 | 0.23 | 0.22 | 0.12 | 0.10 |
| $T_8$-MTP-I | 0.50 | 0.49 | 0.47 | 0.46 | 0.22 | 0.21 | 0.12 | 0.11 |
| $T_9$-MTP-II | 0.30 | 0.29 | 0.27 | 0.26 | 0.17 | 0.14 | 0.12 | 0.09 |
| $T_{10}$-MTP-III | 0.30 | 0.28 | 0.27 | 0.25 | 0.16 | 0.15 | 0.11 | 0.07 |
| $T_{11}$-DPS-4 | 0.28 | 0.27 | 0.26 | 0.25 | 0.14 | - | - | - |
| For comparing means of | SEm ± | CD (0.05) | SEm ± | CD (0.05) | SEm ± | CD (0.05) | SEm ± | CD (0.05) |
| Seed source (T) | 0.002 | 0.006 | 0.012 | 0.034 | 0.002 | 0.007 | 0.002 | 0.006 |
| Incubation level (I) | 0.001 | 0.003 | 0.050 | 0.015 | 0.001 | 0.003 | 0.001 | 0.002 |
| Interaction (T × I) | 0.003 | 0.008 | 0.017 | NS | 0.003 | 0.010 | 0.003 | 0.008 |

TABLE 5

Changes in lignin concentration (%) in decomposing leaf litter of *Pongemia pinnata* at various intervals

| Seed source | 3 MAI | | 6 MAI | | 9 MAI | | 12 MAI | |
|---|---|---|---|---|---|---|---|---|
| | Surface | SubSurface | Surface | SubSurface | Surface | SubSurface | Surface | SubSurface |
| $T_1$-RAK-103 | 20.8 | 18.4 | 17.3 | 14.2 | 13.9 | 11.7 | 10.0 | - |
| $T_2$-RAK-106 | 22.1 | 20.1 | 19.3 | 17.4 | 15.1 | 13.8 | 13.5 | - |
| $T_3$-RAK-11 | 23.0 | 21.8 | 20.2 | 19 | 16.4 | 14.9 | 14.2 | - |
| $T_4$-RAK-90 | 30.9 | 28.5 | 27.8 | 24.3 | 24.9 | 22.5 | 20.7 | 18.2 |
| $T_5$-RAK-22 | 28.1 | 25.0 | 24.7 | 22.9 | 21.2 | 20.9 | 18.8 | 16.7 |
| $T_6$- RAK-05 | 22.2 | 21.9 | 19.9 | 18.1 | 16.1 | 14.2 | 13.9 | - |
| $T_7$-RAK-89 | 29.7 | 27.9 | 26.5 | 22.5 | 23.3 | 20 | 19.8 | 17.5 |
| $T_8$-MTP-I | 35.8 | 33.3 | 29.7 | 27.9 | 25.7 | 23.9 | 21.2 | 20.9 |
| $T_9$-MTP-II | 33.3 | 31.5 | 27.7 | 25.3 | 24.9 | 21.1 | 20.9 | 20.0 |
| $T_{10}$-MTP-III | 31.0 | 30.3 | 25.4 | 24.2 | 23.9 | 21.8 | 18.5 | 19.4 |
| $T_{11}$-DPS-4 | 23.9 | 21.8 | 20.9 | 19.7 | 16.3 | - | - | - |
| For comparing means of | SEm ± | CD (0.05) | SEm ± | CD (0.05) | SEm ± | CD (0.05) | SEm ± | CD (0.05) |
| Seed source (T) | 0.014 | 0.041 | 0.045 | 0.129 | 0.087 | 0.250 | 0.186 | 0.533 |
| Incubation level (I) | 0.006 | 0.018 | 0.019 | 0.055 | 0.037 | 0.107 | 0.079 | 0.227 |
| Interaction (T × I) | 0.020 | 0.059 | 0.064 | 0.183 | 0.124 | 0.354 | 0.263 | 0.754 |

and subsurface placement at all stages of investigation (Table 5). Surface placement yielded higher lignin values for the seed source MTP-I of 35.8, 29.7, 25.7, and 21.2 at 3, 6, 9 and 12 MAI, but subsurface placement yielded similar results for the same treatment MTP-I with values of 33.3, 27.9, 23.9 and 20.9 at 3, 6, 9 and 12 MAI. Significant differences were identified for different Pongamia sources, incubation levels and the way they interact.

**Changes in Cellulose Concentration in Decomposing Litter**

Cellulose (%) in Pongamia sources decreased significantly after 3 months of incubation until the 12th month of incubation (Table 6). Cellulose (%) at the subsurface level responded similarly to the incubation surface layer. Surface placement had greater real values and subsurface placement had lower actual values. Higher values in cellulose for surface and subsurface placement for the treatment MTP-I Pongamia source were 35.2; 35.0, 34.9; 34.5; 33.8; 33.1; 33.2; 32.9 at all phases of litter incubation. There was also a substantial difference between the two levels of placement and their interaction with Pongamia cellulose sources.

**Changes in Ash (%) in Decomposing Litter**

The concentration of ash (%) in decaying Pongamia sources litter (surface placement) decreased throughout the first three months of incubation. It fell further in the sixth MAI for the next three months. A similar tendency was seen in subsurface litter placement, with greater values than surface placement (Table 7). Carbon content varied more significantly with treatment RAK-90, with values of 24.3, 22.9, 22.3 and 21.2 per cent at 3, 6, 9 and 12 MAI, respectively. The ash concentration varied greatly depending on the Pongamia source, incubation level, and interaction effect.

The loss of dry matter at the end of every third month in two different field circumstances, namely surface-placed litter and subsurface-placed litter, was

TABLE 6

Changes in cellulose concentration (%) in decomposing leaf litter of *Pongemia pinnata* at various intervals

| Seed source | 3 MAI | | 6 MAI | | 9 MAI | | 12 MAI | |
|---|---|---|---|---|---|---|---|---|
| | Surface | SubSurface | Surface | SubSurface | Surface | SubSurface | Surface | SubSurface |
| $T_1$ -RAK-103 | 32.7 | 31.9 | 32.3 | 31.4 | 30.9 | 30.1 | 29.8 | - |
| $T_2$ -RAK-106 | 35.8 | 34.4 | 33.9 | 33.7 | 33.3 | 32.9 | 32.2 | - |
| $T_3$ -RAK-11 | 32.4 | 31.7 | 31.8 | 31.1 | 30.3 | 29.7 | 29.3 | - |
| $T_4$ -RAK-90 | 31.9 | 31.6 | 31.4 | 30.8 | 30.0 | 29.7 | 29.3 | 28.7 |
| $T_5$ -RAK-22 | 31.7 | 31.2 | 30.8 | 30.1 | 29.7 | 29 | 28.9 | 28.0 |
| $T_6$ - RAK-05 | 31.9 | 31.2 | 31.3 | 30.8 | 29.9 | 29.2 | 29.0 | - |
| $T_7$ -RAK-89 | 31.9 | 31.4 | 31.1 | 30.5 | 30.2 | 29.3 | 29.2 | 28.3 |
| $T_8$ -MTP-I | 35.2 | 35.0 | 34.9 | 34.5 | 33.8 | 33.1 | 33.2 | 32.9 |
| $T_9$ -MTP-II | 34.3 | 33.8 | 33.4 | 33.1 | 33.1 | 32.5 | 32.4 | 32.1 |
| $T_{10}$ -MTP-III | 35.0 | 34.9 | 34 | 33.9 | 33.5 | 33.0 | 33.3 | 32.5 |
| $T_{11}$ -DPS-4 | 32.6 | 31.9 | 32.4 | 31.6 | 31.4 | 30.7 | 30.5 | 30.1 |
| For comparing means of | SEm ± | CD (0.05) | SEm ± | CD (0.05) | SEm ± | CD (0.05) | SEm ± | CD (0.05) |
| Seed source (T) | 0.203 | 0.583 | 0.098 | 0.280 | 0.029 | 0.082 | 0.023 | 0.066 |
| Incubation level (I) | 0.087 | 0.248 | 0.042 | 0.119 | 0.012 | 0.035 | 0.010 | 0.028 |
| Interaction (T × I) | 0.288 | 0.824 | 0.138 | 0.396 | 0.040 | 0.116 | 0.032 | 0.093 |

TABLE 7

Changes in ash concentration (%) in decomposing leaf litter of *Pongemia pinnata* at various intervals

| Seed source | 3 MAI | | 6 MAI | | 9 MAI | | 12 MAI | |
|---|---|---|---|---|---|---|---|---|
| | Surface | SubSurface | Surface | SubSurface | Surface | SubSurface | Surface | SubSurface |
| $T_1$ -RAK-103 | 9.8 | 9.1 | 9.2 | 8.8 | 9.5 | 8.2 | 9.0 | - |
| $T_2$ -RAK-106 | 17.5 | 16.8 | 17.0 | 16.2 | 16.6 | 15.8 | 16.2 | - |
| $T_3$ -RAK-11 | 9.9 | 9.1 | 9.0 | 8.7 | 9.5 | 8.1 | 9.1 | - |
| $T_4$ -RAK-90 | 24.3 | 23.8 | 22.9 | 23.1 | 22.3 | 22.5 | 21.2 | 21.9 |
| $T_5$ -RAK-22 | 23.1 | 22.7 | 22.7 | 22.1 | 22.2 | 21.7 | 21.9 | 21.3 |
| $T_6$ - RAK-05 | 10.4 | 9.9 | 9.9 | 9.3 | 9.1 | 8.8 | 8.6 | - |
| $T_7$ -RAK-89 | 2.3 | 2.0 | 2.0 | 1.7 | 1.6 | 1.3 | 1.2 | 1.0 |
| $T_8$ -MTP-I | 3.4 | 3.2 | 3.0 | 2.8 | 2.5 | 2.2 | 2.0 | 1.7 |
| $T_9$ -MTP-II | 3.7 | 3.3 | 3.2 | 3.0 | 2.7 | 2.3 | 2.1 | 2.0 |
| $T_{10}$ -MTP-III | 9.4 | 9.0 | 8.8 | 8.7 | 8.5 | 8.2 | 8.0 | 7.8 |
| $T_{11}$ -DPS-4 | 10.0 | 95 | 9.2 | 9.0 | 9.0 | - | - | - |
| For comparing means of | SEm ± | CD (0.05) | SEm ± | CD (0.05) | SEm ± | CD (0.05) | SEm ± | CD (0.05) |
| Seed source (T) | 0.052 | 0.148 | 0.105 | 0.0300 | 0.188 | 0.538 | 0.222 | 0.637 |
| Incubation level (I) | 0.022 | 0.063 | 0.045 | 0.128 | 0.080 | 0.230 | 0.095 | 0.272 |
| Interaction (T × I) | 0.073 | 0.210 | 0.148 | NS | 0.266 | 0.761 | 0.315 | 0.901 |

used as the indicator of litter decomposition for multiple Pongamia sources in 2013.

The chemical composition of plant material, the palatability of leaves to soil fauna, climatic variations, and other factors can all be used to explain the temporal variation in the loss of dry matter during the decomposition of leaves from different Pongamia sources (Gupta and Singh 1981, Pandey and Singh 1982).

In general, all Pongamia sources decompose in a biphasic manner, with a fast breakdown in the first phase and subsequent stabilization within both surface and subsurface soil depths. This could be related to the early degradation of more soluble chemicals, leaving the more resistant compounds, which disintegrate slowly (Johnson et al 2007). There are several factors that affect the rate of litter decomposition, including litter quality (Sraha and Ulzen-Appiah 1997; Silver and Miya 2001); climate (Aerts 1997); decomposer community (Lavelle *et al.,* 1992) and location (Beare, 1997). Tropical climates are known to control decomposition more so than temperate climates, which experience less change annually (Meentemeyer, 1978). It is possible that the variations in the breakdown patterns of Pongamia sources are related to the initial chemical properties of nitrogen, lignin and C/N ratio of leaf litter, which varied significantly across *Pongamia* sources.

The rapid loss of dry matter in DPS-4 could be attributed to ash, phosphorus and low lignin (Table 1). MTP-III's slower decomposition rate could be attributed to its higher lignin, cellulose and low nitrogen content. The results were further supported by the highly significant but bad correlation of lignin and cellulose with cumulative weight loss and the highly significant but favorable link of ash and phosphorus concentrations with cumulative weight loss in leaf litter. The results agree with Gupta and Singh (1981), Pandey and Singh (1982) and Waring and Schlesinger (1985). Smith (1994) likewise determined that soluble carbons were the primary drivers of microbial growth and activity.

The decomposers employ soluble carbon as an energy source later in the decomposition process, whereas nitrogen is absorbed into cell proteins and other components. As a result, more initial nitrogen promotes breakdown. During current investigation, the initial nitrogen content of the Karnataka (DPS-4) and Maharashtra (RAK) Pongamia sources was found to be higher than that of the Tamil Nadu (MTP) source.

When compared to Tamil Nadu sources, the initial high nitrogen content may have resulted in a faster disintegration rate in Maharashtra and Karnataka sources. Many other researchers found similar outcomes (Satchell & Lowe, 1967; Anderson, 1973; Gupta & Singh, 1981; Pandey & Singh, 1982b; Rawat *et al.,* 1995 and Pande, 1999).

Decomposing bacteria target cellulose and hemicellulose-containing litter after soluble carbohydrates (which make up 30-70% of plant carbon) have been exhausted. As a result, these elements are more resistant to breakdown and play a role in the latter stages. A negative significant connection was found with these parameters in the current study, they were more prevalent when the seasons changed from winter to rainy season, demonstrating the significance of these elements in the later stages of decomposition.

After more liable components have been consumed, lignin tends to dominate the shape of the long-term decay curve in the final stage of breakdown (Minderman, 1968). According to Chesson (1997), lignin prevents the breakdown of cellulose and other components of the cell wall. It provides little to no energy to the decomposers up to the final stage of breakdown. As a result of the higher lignin content of Pongamia sources, decomposers spend more time and decompose more slowly. This could be one of the reasons why Tamil Nadu (MTP-I, MTP-II and MTP-III) Pongamia sources showed the slowest decomposition due to their high lignin level, whilst Maharashtra (RAK) Pongamia sources showed the fastest decomposition due to their low lignin content. Consequently, the findings are consistent with those of Gupta and Singh (1981), Pandey and Singh (1982), Jama and Nair (1996), Mafangya *et al.* (1997), Manfongya and Nair (1997), Mugendi and Nair (1997), Arunachalam *et al.* (1998), and Pande (1999).

It was found that subsurface-placed litter degraded more quickly than surface-placed litter during the current experiment. This might be caused by the subsurface layer having higher soil moisture than the surface layer, which might have increased microbial and faunal activity. As a result, higher rates of decomposition in subsurface-placed bags are preferable to faster rates of decomposition in litter bags placed at 5 cm depth below the surface, as observed by Gupta and Singh (1981).

**Nutrient Concentration Variations in Decomposing Litter**

Nitrogen concentration in disintegrating leaf litters of Pongamia sources increased up until May, with slight oscillations in between (Table 2), following, which a constant fall in concentration was recorded towards the end of the decomposition phase. Surface and subsurface deployments followed a similar pattern.

Regardless of the difference in nitrogen concentration, the total quantity of nitrogen reduced gradually as decomposition advanced through different seasons towards completion in the leaf litter of every Pongamia source in both field situations, *i.e.,* surface and subsurface alteration in the total volume of an element during disintegration (net mineralization or net immobilization) is a role of both mass loss and change in the virtual concentration of the element

As a result of the quicker rate of decomposition in DPS-4, RAK-103, RAK-106, RAK-11 and RAK-05, despite the initial increase in concentration, a continuing release was noted. Nitrogen concentrations in Tamil Nadu (MTP-I, MTP-II and MTP-III) sources were minimal; nevertheless, nitrogen concentrations in surface-placed litter increased initially up to 6 MAI before decreasing overall. The trend was similar in both surface and subterranean litter, but its concentration was modest during the first months.

The results coincide with those of Kumar and Deepu (1992), who discovered that leaf litter from Casuarina, Acacia and Leucaena increased in nitrogen concentration but decreased in absolute nitrogen amount.

For both sites, phosphorus showed an initial decrease followed by a progressive increase for all Pongamia sources studied (Table 3). Phosphorus levels decreased again near the end of the failure. The initial drop in phosphorus content might have been caused by phosphorus loss from substances that leach quickly, while the later rise might have been caused by increased phosphorus retention since it is immobile (Upadhyay 1987). The substantial rains at the end, which may have assisted leaching, as well as the quick decomposition of leaf litter during this season, can be attributed to the subsequent reduction. During the wet season, numerous tree species' leaf litter showed a drop in phosphorus concentration, according to Arunachalam *et al*. (1998).

There was a fast decline (but no release) in the absolute amount of phosphorus in the residues, which was followed by a progressive phase. For all Pongamia sources and placements, different levels of immobilisation were first noted, followed by a net release with minor differences (Table 3). The results are in line with the findings of Berg and Staff (1981), who distinguished between three phases: initial leaching, accumulation / immobilization and mineralization.

According to the findings of this investigation, potassium levels in all Pongamia sources decreased gradually, beginning with surface litter. Following that, its concentration rapidly decreased (Table 4). However, a rapid decrease was evident in all Pongamia sources in subsurface litter from the very start. Physical leaching can remove potassium since it is not structurally bonded in organic molecules. This could explain the quick decline phase in potassium concentrations after rains, with higher moisture in the subsurface layer relative to the top layer being responsible for the rapid initial decline in potassium concentrations in this layer. The findings are comparable to those of Bocock (1964), Blair (1988) and Bahuguna *et al.* (1990).

The study examined the variations in nitrogen, phosphorus, potassium and lignin concentrations in the decaying litter of *Pongamia pinnata* from

11 distinct seed sources. The results revealed considerable differences in the content of these components among different seed sources and at different phases of breakdown. During the first six months of decomposition, nitrogen content increased, and then it reduced. Phosphorus concentration declined during the first few months and then increased significantly at 9 MAI. Potassium content decreased progressively until 9 MAI when it dropped rapidly. The concentration of lignin decreased gradually throughout the research. The study discovered that the concentrations of these elements varied based on the seed source and the positioning of the litter. Overall, the study discovered that the chemical makeup of Pongamia leaf litter, its placement in the soil and meteoro--logical circumstances all influenced the rate of decomposition. The biphasic breakdown pattern seen in all Pongamia sources was attributed to the early decomposition of more soluble chemicals, leaving the more resistant molecules that degrade more slowly.

The study also discovered that the primary chemical properties of nitrogen, lignin and C/N ratio of the leaf litter vary significantly amongst Pongamia sources, which contributed to the differences in decomposition rates. Higher initial nitrogen content facilitated faster degradation, but higher lignin content retarded decomposition. Subsurface litter placement resulted in a faster rate of decomposition, most likely due to improved soil moisture and enhanced microbial activity. In terms of nutrient concentration, nitrogen content increased initially and subsequently decreased near the end of the decomposition phase. Overall, the study sheds light on the complex process of trash decomposition and the factors that influence under agroforestry systems.

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