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***Research Paper***

# ROLE OF PLANT LITTER DECOMPOSITION AND NUTRIENT RELEASE IN *Jatropha* AND RUBBER PLANTATION IN TRIPURA, NE INDIA

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**Abstract**

Among the two plantation types, rubber plantation witnessed highest C: N ratio indicated low litter quality and decomposability as compared to *Jatropha* plantation.The mass remain higher in rubber plantation and low in *Jatropha* plantation. The percent of litter weight loss was higher in the initial phase and during the wet months compared to dry months. Litter mass loss showed a rapid phase of initial mass loss in *Jatropha* plantation in which 88.5 % and 88.78% recorded in 1st and 2nd year, respectively. While it was 73.35% and 74.64% in Ist and 2nd year in rubber plantation.Decomposition rate constant ($k$) in rubber plantation was recorded1.76 and 1.62 in Ist and 2nd year. In case of *Jatropha* plantation, $k$ was 2.17 and 2.05 in 1st and 2nd year, respectively. Time required for 50% decomposition was recorded as 144 days and 156 days in 1st and 2nd year annual cycle in rubber plantation but in *Jatropha* it was required for 50% decomposition in 1st and 2nd year as 116 days and 123days. For decomposition of 95% and 99% it was recorded as 662 days, 675 days for 1st year and 1036 days and 1127 days for 2nd year in rubber plantation whereas in *Jatropha* , time required for 95% and 99% was 504 days, 534 days for 1st annual cycle and 841 days and 890 days in 2nd cycle, respectively.

Key words: *Litter,Decomposition, Nutrient release,Jatropha, Rubber plantation*.

## INTRODUCTION

The decomposition of organic matter and the enrichment of the soil with labile nutrients necessary for plant growth are a biological process operating within the constrains imposed by arrange of complex and interacting physical factors1.2. Soil fauna are contributors to this process and in the maintenance of soil fertility 3, 4.

Decomposition process of plant residues is influenced by substrate quality, decomposer community and environmental factors 3, 4, 5.

Decomposition is a complex ecological process that is strongly influenced by litter chemistry 6, 7. It was reported that litter decomposition is inversely related to lignin content and with high lignin content litter decaying slower than low lignin litters8, 9. Although hemicellulose is a glucose compound but it takes time to decompose, as it is a highly cross-linked with lignin creating a complex web of bonds which allows slow degradation of cell wall compounds. Cellulose and other polysaccharides are easily attacks the microbes after the soluble fraction have been depleted 3.

In view of some works which have been carried out in other parts of India 10, 11, 12. but no attempt has been made so far on this aspect in Tripura where rainfall, relative humidity and moderate to high temperature prevails.

The soil fauna may have a greater effect on decomposition in tropical forest than temperate ones have been suggested by different researchers of the globe13,14.Decomposition and mineralisation of litter are determined by qualitative and quantitative composition of soil organisms and the chemical nature of litter such as the content of tannin, lignin and C/N 15. The decomposition rate varies greatly even among tropical forests, depending on factors such as climate and litter quality soil biota includes microflora, micro invertebrates and macro invertebrates. Microflora (Bacteria and fungi) is the major group that decomposes litter directly 16.Micro invertebrates directly consume or indirectly regulate microfloral communities, thereby effecting decomposition rates 17.

**MATERIALS AND METHODS:**

Nylon bag technique was used to study the decomposition of two vegetational types 18.Freshly leaf litters from two vegetational sites under investigation were randomly collected during the peak litter fall period (January- February) and air dried.20 gms of litter samples were placed in 20 cm X 20 cm. litter bags (2 $mm^2$ mesh size) and ninety such bags were prepared for each vegetational type. Litter bags enclosing leaf of each vegetational type were placed under the closed canopy of the respective vegetational type on **2nd and 4th January** in both the years on Rubber and *Jatropha* plantations respectively. At each sampling occasion, 5 litter bags were drawn randomly at monthly intervals during February, 2018- to January, 2020. After collection of litter bags the residual materials were separated carefully from the adhering soil particles using a small brush and the litter samples from each bag were oven dried at 60°C up to a constant weight to determine the dry weight.

**Weight loss over time:**

Monthly weight loss (g/month) of decomposing litter was determined from the difference between the weights remaining in the litterbags in each month.

Negative exponential decay model was used to calculate the weight loss over time 19.

**Calculation:**

$$L/L_o = \exp(-kt),$$

Where ,L is the remaining at time t, $L_o$ is the initial weight, exp the base of natural logarithm, $k$ the decay rate coefficient and t the time (year). The required time for 50% ($t_{50}$) and 99 %($t_{99}$) decay was calculated as $t_{50}=0.693/k$, $t_{95}=3/k$ and $t_{99}=5/k$.

**Analysis of major plant nutrients and carbon:**

Samples of initial litters and decomposing litters were dried at 60°C and powdered to analyse their chemical composition. The ash content was determined by igniting 1 gm. of powdered litter sample at 550°C for 6 hour in a Muffle furnace. A total of 50% of the ash free mass was calculated as the carbon(C) content. Total nitrogen (N) was determined by a semi micro-Kjeldahl procedure using selenium 20. Total Phosphorous (P) was determined by Molybdenum blue method followed by 21.Total Potassium content of litter was estimated by Flame photometer after digestion in the mixture of tri-acid following 21. Absolute amount of nutrient in the litter bag was investigated as

$$(C/C_0) \times (L/L_0) \times 100$$

Where, C is the nutrient concentration in the litter samples at the time of sampling. $C_o$ is the nutrient concentration of the initial litter, L is the mass of dry matter at the time of sampling and Lo is the initial dry mass of the litter sample.

**Method of lignin assay:**

Acetyl bromide lignin extraction was performed according a downscaled method similar to that described previously 22. Briefly, 0.1 ml acetyl bromide (25% in acetic acid) and 4 µl 70% perchloric acid were added to acetone washed and oven dried 1 mg sample and the mixture was incubated at 70 °C for 40 min. NaOH (2 M, 0.2 ml) and 0.5 ml acetic acid were then added to the test tube after incubation. After centrifugation (15 000 g, room temperature, 15 min), the supernatant was separated from the pellet. The pellet was further washed by adding 0.5 ml acetic acid (vortex, 5 s), followed by centrifugation (15 000 g, room temperature, 15 min). The second supernatant was combined with the first. Acetic acid was added to the combined supernatants to a volume of 2 ml, and absorption was measured at 280 nm using UV visible spectrophotometer. An extinction coefficient for lignin at 280 nm of 23.35 L $g^{-1}$ $cm^{-1}$ was used 23.

**III.RESULTS:**

### 3.1. Initial litter chemistry

The study indicated that the nutrients viz. nitrogen, phosphorus, potassium, carbon content and lignin of the initial litter were found to be varied in two plantations. Nitrogen content was showed higher in *Jatropha* plantation (1.32% -1st cycle; 1.36% -2$^{nd}$ cycle) than rubber plantation (1.25% -1$^{st}$ cycle; 1.32% -2$^{nd}$ annual cycle). It also showed higher phosphorus content in *Jatropha* plantation (0.16% -1st year; 0.17% -2$^{nd}$ cycle) compared to rubber plantation (0.05%-1st annual cycle; 0.09% in 2$^{nd}$ cycle). During the first annual cycle, potassium content was found to be maximum in *Jatropha* plantation in 1$^{st}$ cycle (0.75%) than rubber plantation (0.58%). In the following cycle, here also *Jatropha* showed more potassium content (0.75%) compared to rubber plantation (0.54%). Total carbon content was recorded maximum in rubber plantation (42.68% in 1$^{st}$ cycle and 41.87% in 2$^{nd}$ annual cycle) than *Jatropha* plantation (31.5%) in 1$^{st}$ cycle and 32.6% in 2$^{nd}$ cycle. C/N ratio of rubber plantation was observed to be 34.14 and 31.71 in first and second annual cycle whereas in *Jatropha* it was 23.86 and 23.97 in two consecutive years. In rubber, initial lignin content in 1$^{st}$ and 2$^{nd}$ annual cycle was recorded as 7.6% and 7.65%, respectively where in *Jatropha* the same was 5.71% and 5.83% during the two years of study. But C/N recorded maximum in rubber as 34.14 and 31.71. In case of *Jatropha* the ratio was recorded as 23.86 and 23.93(Table.1).

### 3.2. Leaf litter weight loss

Weight loss pattern in two plantation areas during decay were presented in (Fig.1). With the development of period, total mass loss was increased but no regular trend of monthly loss was noticed during the investigation period in rubber plantation. Peak weight loss was 22.37 % in February, 2018 in 1st year and 22.94% in 2$^{nd}$ year (2019), but the rate of weight loss decreased with the progress of time. In the rainy season it was much better than any other time of the year. In *Jatropha* plantation, it was 25.40%

and 25.23% during the month of February, 2018 and 2019 for 1st and 2nd year, respectively. Slow rate of loss was also observed in different months of studied period, total 88.5% and 88.78% loss was noticed in *Jatropha* litter. But in case of rubber the total percentage of loss was 73.35 and 74.64 in 1st and 2nd annual cycle respectively (Fig.1.). Weight loss expressed as a percentage of original dry weight decrease exponentially with time was shown in Fig.2and Fig.3. The exponential equation for the litter in first annual cycle may be expressed as $Y=96.33^{e-0.00x}$, r=0.997 and $Y=94.09^{e-00x}$, r=0.996 for rubber and and *Jatropha* plantation areas, respectively. In 2nd annual cycle it was recorded $Y=104.0^{e-0.00x}$, r=0.996 and $Y=93.46^{e-0.00x}$,r=0.997.(Fig.7.2. and 7.3.) The higher value of k was recorded in *Jatropha* for first (2.17) and second (2.05) annual cycles than rubber litter (1.76 in 1st cycle and 1.62 in 2nd cycle). Time required for 50%, 95% and 99% was different in two vegetational sites. Rubber took 144 days,622 days, 1036 days in first annual cycle ;and 156 days,675 days and 1127 days in 2nd cycle, respectively whereas, in *Jatropha* it was recorded as 116days,504 days and 841 days in 1st annual cycle and 123 days, 534 days and 890 days was required to be decomposed in 2nd cycle.(Table 7.2).

3.3. NPK concentration of the decomposing litter mass

Variation of N, P, K concentrations of litter from two study sites was calculated and the contents remaining in litter during decay was depicted in the Fig.4. Dynamics of nitrogen concentration was found to be complex as it declined in month of February, 2011 but in March, it increased and tendency of decreasing was observed from the month of April to September. In October, again it had increased and during November it decreased again. Also in the second annual cycle, this type of tendency was observed in rubber plantation. In February, 2018, accumulation was observed in both the years (Table.4).

In case of phosphorus content, initial accumulation was occurred in the month of February and March, 2018 followed by declination upto the end of next year. This type of accumulation and the mineralisation was observed in second cycle also. There was no definite trend of fluctuation occurred in phosphorus content during of investigation (Fig.4)

Highest accumulation of potassium content was obtained in February, 2018 and 2019. The decrease of accumulation trend throughout the period of investigation was not remained uniform (Fig.4).

Nitrogen concentration was decreased in first month followed by rapid increase in next month and then declined again. Thereafter, decrease continued upto the last month of the investigation period. Accumulation and mineralisation for reuse in soil was found.

In *Jatropha* plantation, accumulation and mineralisation of nitrogen occurred in the month of March, 2018 and then it declined whereas phosphorus content was rapidly increased and then it decreased. Potassium declined with the progress of time for both the years. For all the nutrients, the trend of decrease was not regular or uniform throughout the period of investigation (Fig.5)

Table 1: Initial litter chemistry of two plantations

| Vegetation type | Year | N (%) | P (%) | K (%) | C (%) | L(%) | C/N |
|---|---|---|---|---|---|---|---|
| Rubber | 1st | 1.25 | 0.05 | 0.58 | 42.68 | 7.60 | 34.14 |
| | 2nd | 1.32 | 0.09 | 0.54 | 41.87 | 7.65 | 31.71 |
| Jatropha | 1st | 1.32 | 0.16 | 0.79 | 31.5 | 5.72 | 23.86 |
| | 2nd | 1.36 | 0.17 | 0.75 | 32.6 | 5.83 | 23.97 |

Note: N=Total Nitrogen content, P= Available phosphorus content,

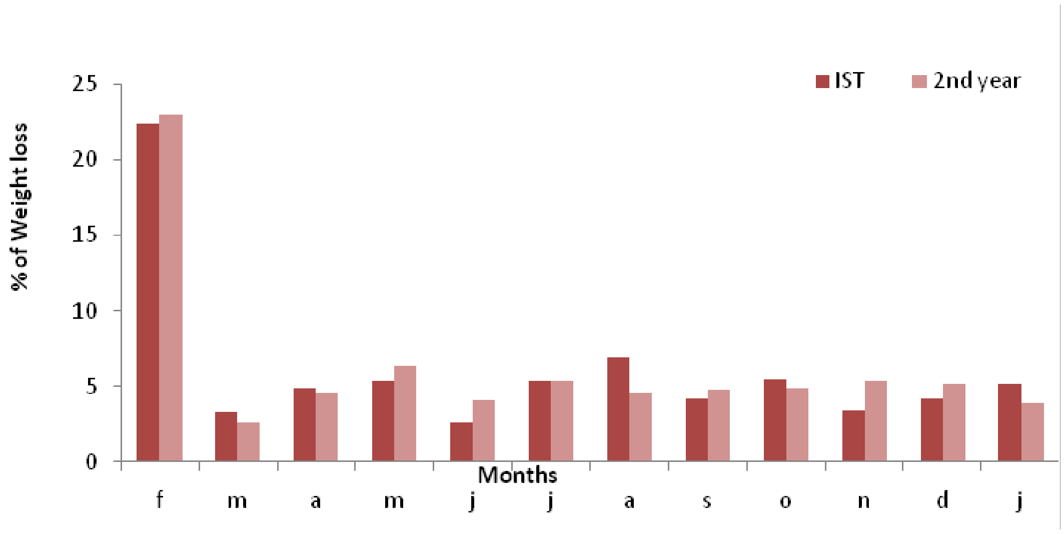
K= Extractable potassium content, C=Carbon, L=Lignin

1st year = (February ,2018 –January,2019;2nd year = (February ,2019 – January,2020).

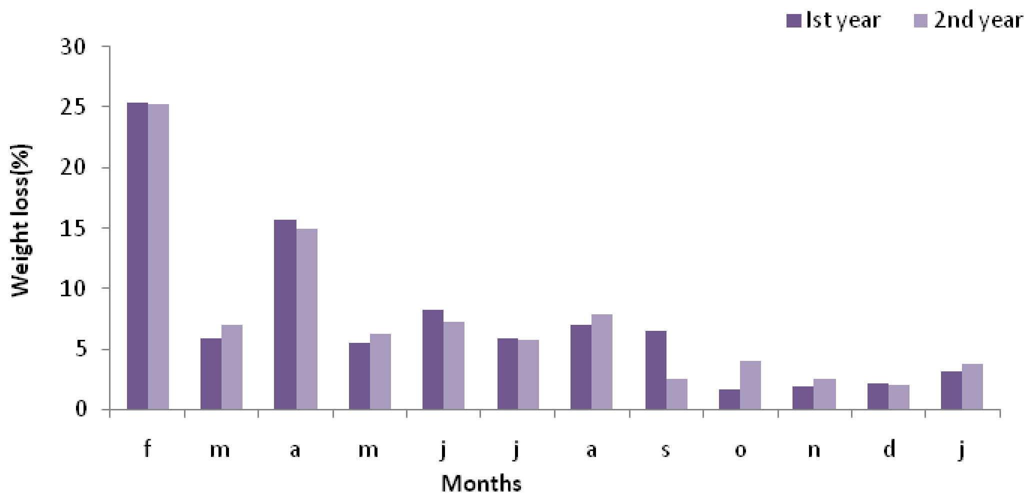
Table.2: Annual decay constant for litter of the two study areas

| Year | Decomposition rate constant (*k* year-1) | Time required for 50% decomposition(days) | Time required for 95% decomposition(days) | Time required for 99% decomposition(days) |
|---|---|---|---|---|
| Rubber plantation | | | | |
| 1st year | 1.76 | 144 | 622 | 1036 |
| 2nd year | 1.62 | 156 | 675 | 1127 |
| *Jatropha* plantation | | | | |
| 1st year | 2.17 | 116 | 504 | 841 |
| 2nd year | 2.05 | 123 | 534 | 890 |

Note: 1st year = (February ,2018 –January,2019;2nd year = (February ,2019 – January,2020).



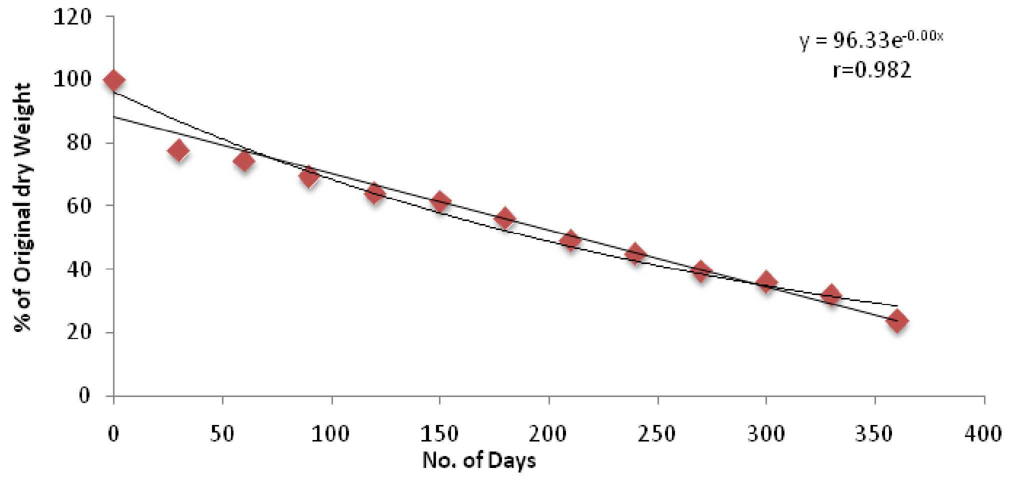

(A)



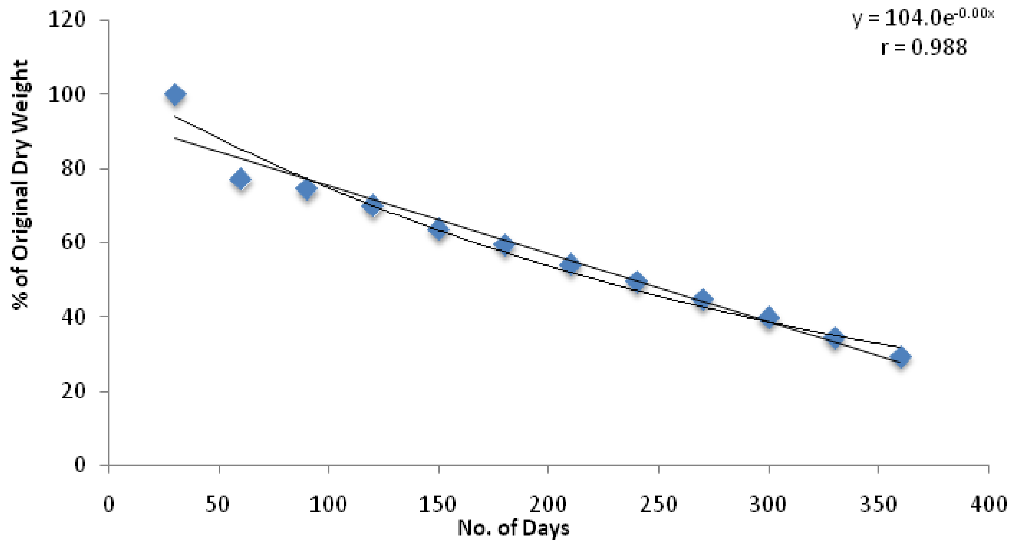

(B)

Fig.1. Showing weight loss in (A) Rubber plantation and (B) *Jatropha* plantation litter from litter bags during the decomposition process of both the study yea

Note: 1st year = (February ,2018 –January,2019;2nd year = (February ,2019 – January,2020).



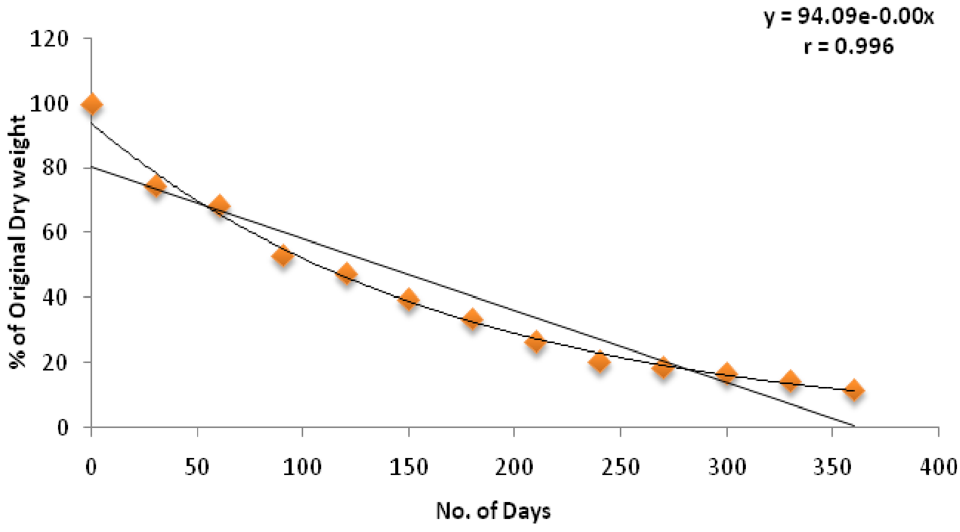

(A)



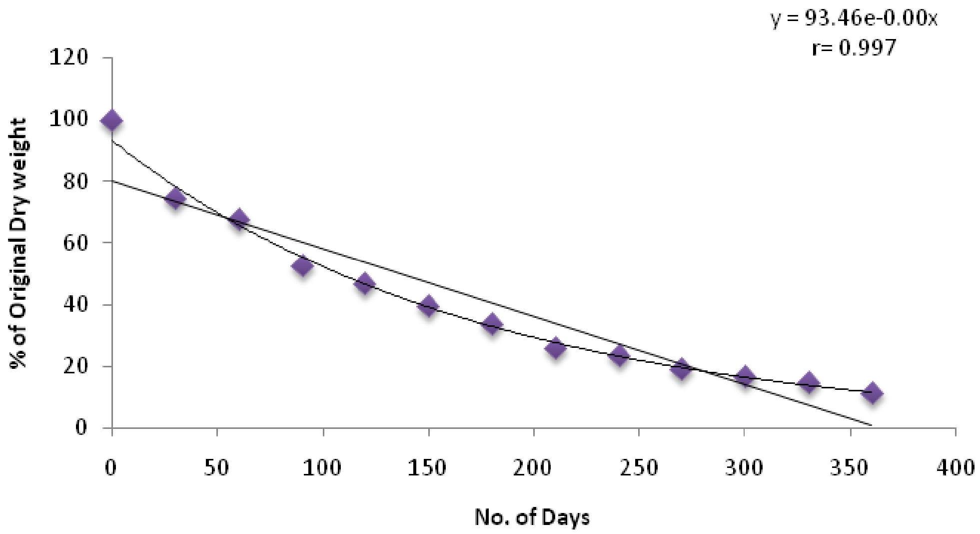

(B)

Fig. 2. Leaf litter decomposition of rubber plantation site. Solid line denotes cumulative weight loss while coloured dotted line denotes predicted weight loss based on exponential model.

Note: 1st year = (February ,2018 –January,2019;2nd year = (February ,2019 –January,2020).



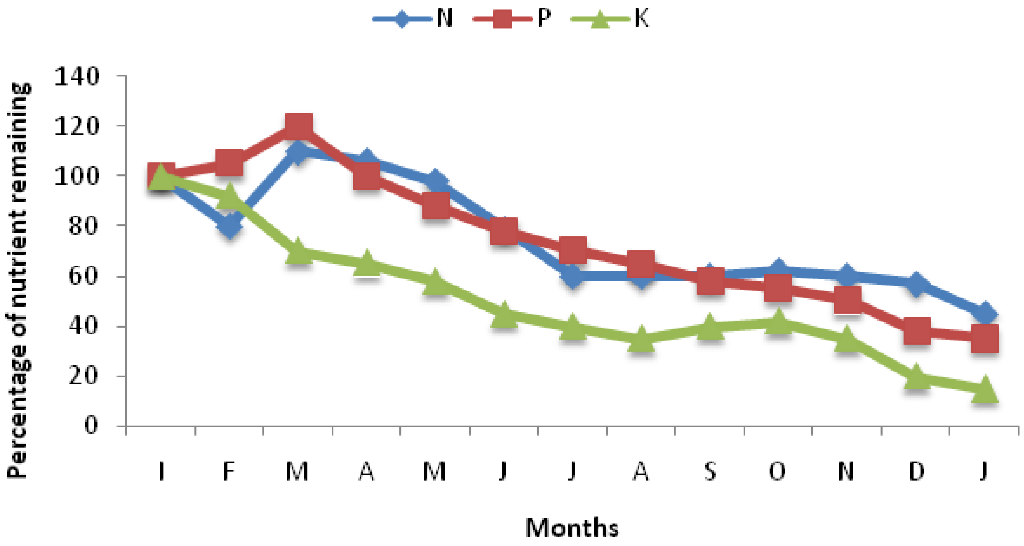

(A)



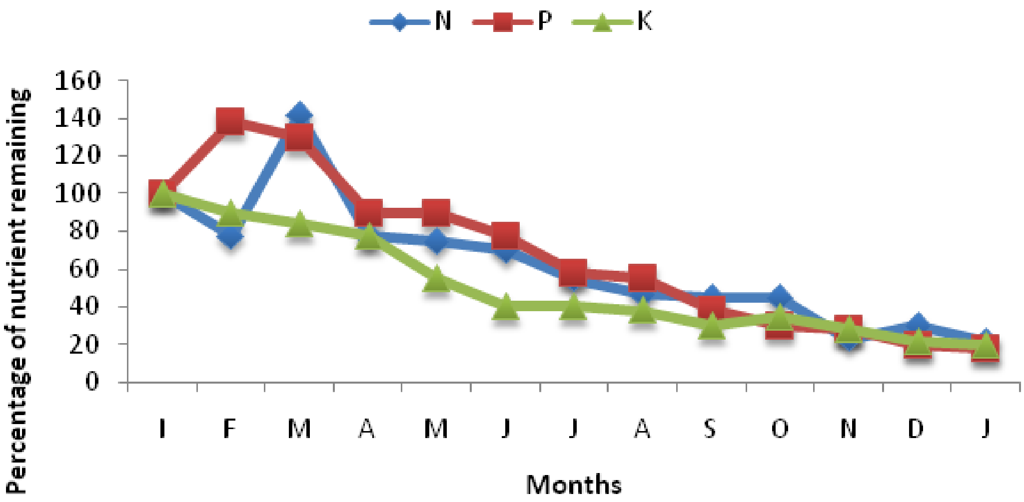

(B)

Fig.3. Leaf litter decomposition of *Jatropha* plantation site. Solid line denotes cumulative weight loss while coloured dotted line denotes predicted weight loss based on exponential model.

Note: 1st year = (February ,2018 –January,2019;2nd year = (February ,2019 – January,2020).




(A)

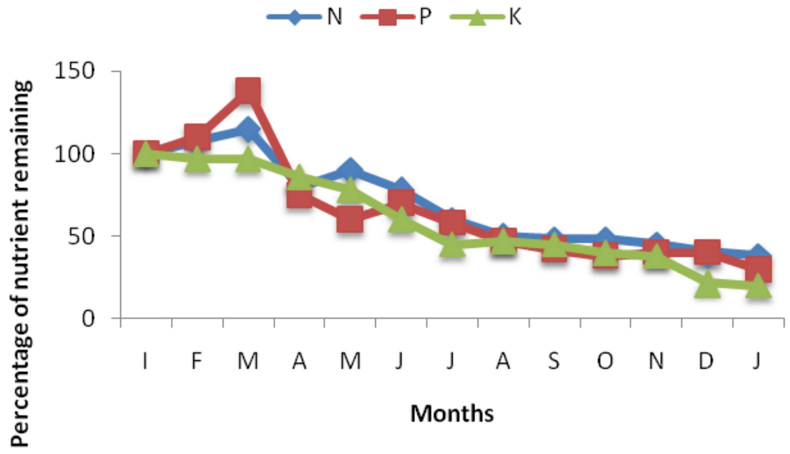



(B)

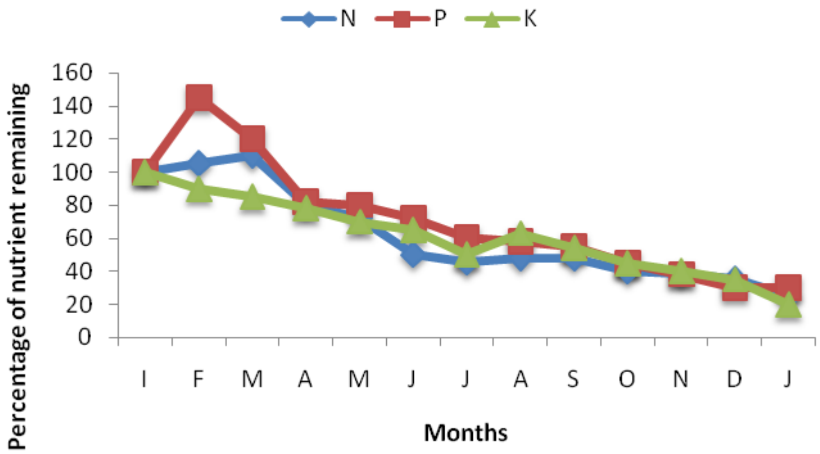
Fig.4. Nutrient remaining in the decomposition leaf litter of rubber plantation (A) 1st year and (B) 2nd year during the study period

Note: N= nitrogen, P= Available phosphorus, K= Extractable potassium

Note: 1st year = (February ,2018 –January,2019;2nd year = (February ,2019 – January,2020).




(A)




(B)

Fig. 5. Nutrient remaining in the decomposition leaf litter of *Jatropha* plantation

(A) 1st year and (B) 2nd year during the study period ((February ,2019 –January,2020)
Note: N= nitrogen, P= Available phosphorus, K= Extractable potassium

## DISCUSSION:

### Initial litter quality

The litter decomposition was studied in rubber and *Jatropha* plantations for two consecutive years i.e. February 2018 to January, 2020. The climatic condition prevails more or less similar in two study sites. The variation in the decay rates may be attributed to the litter quality and soil organisms. Leaves of different species of plant are well known to losses of mass at different rates [3]. The decomposability of litter is critically determined by its concentration of nutrients, lignin or a combination of these constituents [7].In this present study, carbon content found 42.68% and 41.87% in rubber in 1st and 2nd annual cycles whereas in *Jatropha,* it was recorded as 31.5% and 32.65% in first and second year, respectively. Arunachalam *et al.,* (1998) also recorded carbon content ranges from 46% -47% when he worked on forest litter species of a humid subtropical forest after tree cutting which shows more value of carbon as compared to the forest litter in the present findings 24. It may be due to different climatic conditions prevails such as rainfall, relative humidity etc.

Litter decomposition is governed by a host of variables including initial litter chemistry, climatic factors and decomposers organisms. Decomposition is an integrative process that reflects climate and microclimate conditions. Decomposition process of plant residue is influenced by substrate quality, decomposer community and environmental factors [3, 4, and 5].

Bacteria and fungus have preponderant role due to their greater biomass respiratory metabolism 25.Due to heat, moisture and the action of decomposing agents, the chemical elements contained in the litter mass are mobilised and reabsorbed by the roots, giving rise to a new plant cycle and ensuring conditions of permanence of the system even when soils are considered to have low fertility26. The majority of studies reveals that litter decomposition have been carried out using several plant species but there is little information in relation to the rubber tree27, 28. Gréggio *et al.,* studied about the decomposition of the rubber leaf litter and reported that variation in the chemical composition of soil influences the rate of degradation of rubber tree leaves29. Statistically analysed data for the decay rate co-efficient (*k*) differs considerably between the two vegetation. The higher k value was found in *Jatropha* than rubber plantation may be due to high decomposition rate. The data also provide the predicted half-time (time taken to decompose 50% of the initial mass), 95% and 99% decay period which were also showed variation from one plantation to another. Different climatic conditions and initial chemistry can be attributed for such differences. Lower the value of *k.* faster will be the decay and nutrient release 28.In this investigation, *Jatropha* plantation is characterised by higher decay rate (2.17 for 1st cycle and 2.05 in 2nd cycles) than rubber plantation (1.76 in 1st and 1.62 in 2nd cycles). It was 2004 reported that *k* values ranges from 3.4 to 4.7 in natural forest, young teak (1.7-3.4), old teak (1.4-2.8) and firewood (1.3-2.5) of Lama Forest reserve in Benin which is more or less similar with the present findings30. Louzada *et al.,* viewed that negative effect of homogenous litter may be related to (a) the decline in quality and heterogeneity of litter produced (b) unfavourable microclimate (c) adverse effect on the abundance and activity of soil fauna31. In the present study, weight loss of litter of *Jatropha* was more than that of rubber plantation. In the present study, the highest decomposition trend obtained for *Jatropha curcas is* probably caused by the C/N ratio is a representation of this principle. This says that organic matter with a low C to N ratio will decompose faster than a material with a high C/N ratio. This theory states that nitrogen is normally the limiting factor for many of the organisms populations 32.With a higher amount of nitrogen (a low C/N ratio) these populations are more free to grow rapidly and to higher concentration, because of the nutrient cycling through the decomposition of leaves 33.It has been reported that the substrate with C/N< 25 are of high quality and release mineral nitrogen at a faster rate compared to low quality residues(C/N> 25) 34.

**Nutrient release pattern in litter**

Swift *et al*.,[3] reported that , the general pattern of nutrient release in tropical forest leaf litter involves (a) an initial phase when nutrient leaching and release predominate (b) a net mobilisation phase during which nutrients are imported into the residues by microbes and (c) a net release phase when nutrient mass decreases. NPK were recorded more or less similar in both the plantations, it ranged from 1.25 to 1.32 in rubber and 1.32-1.36 in *Jatropha* plantation area. Biphasic pattern of nitrogen dynamics corroborates the findings of 12, 28. Biphasic mode of phosphorus dynamics was also observed in both the plantations. The release pattern agrees with the review on potassium dynamics of decaying litter given by 35.

## CONCLUSION

Litter decomposition is very significant mechanism of biogeochemical nutrient cycle of plantation. The litter breakdown in subtropical humid climate of Tripura was generally fast, indicating the high biological activity and nutrient turnover. High rainfall,relative humidity, temperature during monsoon period and C/N ratio may be attributed for the faster rate of decomposition in case of *Jatropha* .This says that organic matter with a low C to N ratio will decompose faster than a material with a high C/N ratio which supports the other investigations. Biphasic mode of phosphorus dynamics and release pattern also agrees with the other research works. So, decomposition process is very much important for heathy and stable environment.

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