

Original Research Article

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## Effect of Amount and Time of Incorporation of Forest Litter on Soil Fertility Status

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### ABSTRACT

A field experiment was conducted to evaluate the effect of amount of forest litter and its time of incorporation on soil fertility status. The study revealed that with the exception of soil available N, the difference in the time of incorporation of forest litter *i.e.*, at 45 and 30 DBS (Days Before Sowing) did not have any significant effect on soil pH, organic carbon, CEC, available P and available K. Application of forest litter @ 6 t ha<sup>-1</sup> and 9 t ha<sup>-1</sup> significantly increased soil pH and organic carbon content at a rate of 2.52 and 4.91 %; and 5.18 and 11.75%, respectively as compared to control. The CEC, soil available N, P and K increased significantly with each increase in the dose of forest litter application. The addition of forest litter @ 3 t ha<sup>-1</sup>, 6 t ha<sup>-1</sup> and 9 t ha<sup>-1</sup> significantly increased the CEC at the rate of 9.05, 14.32 and 22.03 %, respectively over control. Forest litter application @ 3 t ha<sup>-1</sup>, 6 t ha<sup>-1</sup> and 9 t ha<sup>-1</sup> significantly increased the available N, P and K at the rate of 4.48, 10.26 and 22.89 %; 7.59, 12.50 and 14.87 %; and 6.15, 11.77 and 25.92 %, respectively as compared to control. The results from the study substantiate the importance of forest litter as a viable source of organic matter for cultivated lands. It is also seen that incorporation of litter into the soil prior to sowing had a promising effect on soil health.

#### Keywords

Forest litter,  
Organic matter,  
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### Introduction

Soil is an essential non-renewable resource with potentially rapid degradation rates and extremely slow formation and regeneration processes (Van-Camp *et al.*, 2004). Excessive and injudicious use of fertilizers and agro-chemicals in conventional farming systems can upset the soil physico-chemical and biological equilibrium leading to land

degradation. Soil degradation is as old as agriculture itself, its impact on human food production and the environment becoming more serious than ever before, because of its extent and intensity (Duran and Rodríguez, 2008). Organic farming without using chemo-synthetic inputs has become one of the most feasible alternatives to achieve sustainability in agriculture.

Soil organic matter is a source or sinks for nutrients retention and supply and as a result characterizes agricultural potential of soils (Nwite, 2017). In this present experiment, forest litter has been exploited as a source of organic matter to maintain and/or improve the soil fertility status in cultivated lands. Forest litter plays an important role in determining nutrient cycling, balance and maintaining ecosystem function (Xiaogai *et al.*, 2013). Plant litter had a profound significance in retaining soil water as well as contributing to soil fertility, including organic matter, available phosphorus and alkali-hydrolysable nitrogen (Xiong *et al.*, 2008). Addition of forest litter as a source of organic matter, either alone or in combination with fertilizers has the potential to improve soil fertility and crop performance.

In acidic soils of Nagaland, the levels of available soil N, P and K together with organic carbon content and soil pH could be considered main soil fertility determinants. With a vision to come up with a best performing treatment that can be recommended for practice in the farmer's field and to popularize the importance of forest litter in achieving sustainability, the present investigation has been undertaken to evaluate the effect of forest litter and its time of incorporation on soil fertility status.

## Materials and Methods

A field experiment was conducted in the research field of the Department of Soil and Water Conservation, School of Agricultural Sciences and Rural Development, Medziphema Campus, Nagaland University, during the *kharif* season, 2018. The location of the experimental site is at 20°45'43''N latitude and 93°53'04''E longitude. It is at an altitude of 310 m above mean sea level (MSL). Located in the humid, sub-tropical climate zone, the research farm receives an

average annual rainfall of 2000-2500 mm, with a high relative humidity of 70-80% and moderate temperature. A high yielding rice variety with a short duration of 120 days, SahbhagiDhan, was the variety taken.

The experiment consisted of two factors -date of application of forest litter (D) as the first factor with two different dates of incorporation of litter (D) *i.e.*, 45 and 30 DBS (Days Before Sowing) and the second factor consisted of four doses of forest litter (F) *i.e.*, F<sub>0</sub> – 0 t ha<sup>-1</sup>, F<sub>1</sub> – 3 t ha<sup>-1</sup>, F<sub>2</sub> – 6 t ha<sup>-1</sup> and F<sub>3</sub> – 9 t ha<sup>-1</sup>. The experiment was carried out in a newly cleared forest area, following split plot design with four replications and eight treatments *viz.*, T<sub>1</sub> (Control), T<sub>2</sub> (45 DBS + 3 t ha<sup>-1</sup> of forest litter), T<sub>3</sub> (45 DBS + 6 t ha<sup>-1</sup> of forest litter), T<sub>4</sub> (45 DBS + 9 t ha<sup>-1</sup> of forest litter), T<sub>5</sub> (Control), T<sub>6</sub> (30 DBS + 3 t ha<sup>-1</sup> of forest litter), T<sub>7</sub> (30 DBS + 6 t ha<sup>-1</sup> of forest litter) and T<sub>8</sub> (30 DBS + 9 t ha<sup>-1</sup> of forest litter). Ploughing was done during the fortnight of March. Forest litters @ 3 t ha<sup>-1</sup>, 6 t ha<sup>-1</sup> and 9 t ha<sup>-1</sup> were incorporated separately in each of the plot at 45 DBS and 30 DBS to allow proper decomposition. The general recommended doses for NPK *i.e.*, 60 kg N, 60 kg P<sub>2</sub>O<sub>5</sub> and 40 kg K<sub>2</sub>O of rice were applied. Nitrogen was applied in 3 split doses *i.e.*, basal, active tillering stage and panicle initiation stage. Full doses of phosphorus and potassium and half dose of nitrogen were applied as basal dose. The remaining doses of nitrogen was split into two equal doses and applied as top-dressing, one at active tillering stage and one at panicle initiation stage. The crop was sown at 1<sup>st</sup> fortnight of June, 2018 with a spacing of 20 cm x 10 cm using a seed rate of 75 kg ha<sup>-1</sup>.

Prior to sowing of seeds, soil samples were collected from different locations of the experimental field at 15cm depth, to ascertain the fertility status of the soil. After harvest of the rice crop, soil samples were collected

from individual plots and processed for analysis. The different soil properties were determined following standard procedures (Table 1). The initial soil properties of the experimental field are presented in Table 2. The statistical analysis of the data was done as per procedure outlined by Gomez and Gomez (2004).

## Results and Discussion

### Soil pH

The soil pH varied from 4.98 to 5.30 (Table 4). The difference in the time of application of forest litter *i.e.*, at 30 DBS and 45 DBS had no significant effect on soil pH. The study showed that soil pH increased with increase in amount of application of forest litter. The highest and lowest pH was recorded in treatments with 9 t ha<sup>-1</sup> forest litter incorporated at 45 DBS and control, respectively. Application of forest litter @ 6 t ha<sup>-1</sup> and 9 t ha<sup>-1</sup> significantly increased soil pH as compared to control. The addition of forest litter @ 3 t ha<sup>-1</sup>, 6 t ha<sup>-1</sup> and 9 t ha<sup>-1</sup> significantly raised the soil pH at the rate of 1.57, 2.52 and 4.91 %, respectively over control (Table 3). This increase in soil pH could be due to addition of large quantity of organic residues and subsequent release of Ca and Mg cations and other bases to the soil. Organic matter is also known to have a high buffering capacity. The basic cations neutralize the native soil acidity and increase the soil pH. Similar improvement in the soil pH with the used of organic sources was reported by Dutta *et al.*, (2013), Humtsoe and Chauhan (2005) and Pathak *et al.*, (2005).

### Soil organic carbon

The organic C content in the soil ranged from 2.93 to 3.34 % (Table 4). Incorporation of forest litter @ 9 t ha<sup>-1</sup> at 45 DBS recorded the highest organic C content and lowest was recorded in control. Application of forest litter

@ 6 t ha<sup>-1</sup> and 9 t ha<sup>-1</sup> significantly increased the organic C content of the soil as compared to control. Addition of forest litter @ 3 t ha<sup>-1</sup>, 6 t ha<sup>-1</sup> and 9 t ha<sup>-1</sup> considerably increased the organic C content of the soil at the rate of 2.66, 5.18 and 11.75%, respectively as compared to control (Table 3). The difference in the time of incorporation of forest litter *i.e.*, at 30 DBS and 45 DBS did not have any significant effect on soil organic carbon content of soil. Significant increase in the soil organic carbon with the application of organic materials into the soil were also reported by Yadav *et al.*, (2020), Singh *et al.*, (2006), Kumar *et al.*, (2008) and Singh and Chandra (2011).

### Cation exchange capacity (CEC)

The CEC in the soil varied from 15.46 c mol (p<sup>+</sup>) kg<sup>-1</sup> to 20.46 c mol (p<sup>+</sup>) kg<sup>-1</sup> (Table 4). The highest and the lowest CEC were recorded in treatments with 9 t ha<sup>-1</sup> incorporated at 45 DBS and control, respectively. The study showed that CEC increased significantly with increase in the dose of forest litter application. The addition of forest litter @ 3 t ha<sup>-1</sup>, 6 t ha<sup>-1</sup> and 9 t ha<sup>-1</sup> significantly increased the CEC at the rate of 9.05, 14.32 and 22.03 %, respectively over control (Table 3). The significant increase in CEC on application of forest litter might be due to increase in organic matter which served as a store-house that released base cations into the soil solution. This finding is similar to the findings of Ogbodo (2011) and Dutta *et al.*, (2013).

### Available N

The available N content in soil ranged from 486.08 kg ha<sup>-1</sup> to 658.56 kg ha<sup>-1</sup> (Table 4). The study showed that incorporation of forest litter at 45 DBS significantly increased soil available N as compared to incorporation at 30 DBS.

**Table.1** Soil properties and methods followed for determination

Soil parameters	Methods employed	Reference
Soil pH	Glass electrode pH meter (1:2.5 soil and water ratio)	Jackson, 1973
Organic carbon	Walkey and Black rapid titration	Jackson, 1973
Cation exchange capacity	NH <sub>3</sub> distillation method	Baruah and Barthakur, 1997
Available Nitrogen	Alkaline potassium permanganate method	Subbiah and Asijia, 1956
Available Phosphorus	Bray's No. 1 method	Bray and Kurtz, 1945
Available Potassium	Neutral ammonium acetate	Hanway and Heidal, 1952

**Table.2** Initial soil properties of the experimental site

Soil parameters	Value
Soil pH	4.5
Organic carbon (%)	2.9
Cation exchange capacity [c mol (p <sup>+</sup> ) kg <sup>-1</sup> ]	15.7
Available Nitrogen (kg ha <sup>-1</sup> )	517.5
Available Phosphorus (kg ha <sup>-1</sup> )	32.5
Available Potassium (kg ha <sup>-1</sup> )	153.5

**Table.3** Effect of time and amount of application of forest litter on pH, organic carbon, CEC and available N, P and K

Treatments	pH	Organic carbon (%)	CEC [c mol (p <sup>+</sup> ) kg <sup>-1</sup> ]	Available N (kg ha <sup>-1</sup> )	Available P (kg ha <sup>-1</sup> )	Available K (kg ha <sup>-1</sup> )
D <sub>1</sub> (45 DBS)	5.11	3.07	18.05	572.32	23.21	161.75
D <sub>2</sub> (30 DBS)	5.18	3.11	17.62	546.13	23.14	158.74
SEm ±	0.02	0.03	0.12	3.00	0.06	1.30
CD (P = 0.05)	NS	NS	NS	13.49	NS	NS
Forest litter ( t ha <sup>-1</sup> )						
F <sub>0</sub> (Control)	5.03	2.93	15.68	501.76	21.07	140.91
F <sub>1</sub> (3)	5.11	3.01	17.24	525.28	22.80	150.14
F <sub>2</sub> (6)	5.16	3.09	18.30	559.14	24.08	159.71
F <sub>3</sub> (9)	5.29	3.32	20.11	650.72	24.75	190.21
SEm ±	0.03	0.04	0.19	3.46	0.11	1.34
CD (P = 0.05)	0.09	0.11	0.56	10.27	0.34	3.99

**Table.4** Interaction effect of time and amount of application of forest litter on pH, soil organic carbon, CEC and available N, P and K

Interactions	pH	Organic carbon (%)	CEC [c mol (p <sup>+</sup> ) kg <sup>-1</sup> ]	Available N (kg ha <sup>-1</sup> )	Available P (kg ha <sup>-1</sup> )	Available K (kg ha <sup>-1</sup> )
T <sub>1</sub> (Control)	4.98	2.93	15.90	517.44	21.04	141.15
T <sub>2</sub> (45 DBS + 3 t ha <sup>-1</sup> of forest litter)	5.05	2.95	17.29	533.12	22.91	151.77
T <sub>3</sub> (45 DBS + 6 t ha <sup>-1</sup> of forest litter)	5.13	3.07	18.55	580.16	24.07	162.26
T <sub>4</sub> (45 DBS + 9 t ha <sup>-1</sup> of forest litter)	5.30	3.34	20.46	658.56	24.83	191.83
T <sub>5</sub> (Control)	5.08	2.94	15.46	486.08	21.10	140.68
T <sub>6</sub> (30 DBS + 3 t ha <sup>-1</sup> of forest litter)	5.18	3.08	17.19	517.44	22.70	148.52
T <sub>7</sub> (30 DBS + 6 t ha <sup>-1</sup> of forest litter)	5.20	3.12	18.05	538.12	24.08	157.16
T <sub>8</sub> (30 DBS + 9 t ha <sup>-1</sup> of forest litter)	5.28	3.30	19.76	642.88	24.68	188.59
SEm ±	0.04	0.05	0.26	4.89	0.16	1.90
CD (P = 0.05)	NS	NS	NS	14.53	NS	NS

The maximum and minimum available N was recorded in treatments with 9 t ha<sup>-1</sup> of forest litter incorporated at 45 DBS and control, respectively (Table 3). It was observed that available N increased significantly with increase in the dose of forest litter application. The application of forest litter @ 3 t ha<sup>-1</sup>, 6 t ha<sup>-1</sup> and 9 t ha<sup>-1</sup> significantly increased the available N at the rate of 4.48, 10.26 and 22.89 %, respectively as compared to control. The interaction effects revealed that the time of incorporation of forest litter is crucial for rendering N available in soil. This significant increase in available N in soil on incorporation of forest litter could be attributed to an increase in organic matter content and subsequent release of nutrients into the soil after decomposition of organic substrates. This findings are in supportive of the findings of Ogbodo (2011) and Zhao *et al.*, (2019). Imtilemla *et al.*, (2009) also observed similar build up of available N in soil on terraced land.

#### Available P

The available P content in soil ranged from 21.04 kg ha<sup>-1</sup> to 24.83 kg ha<sup>-1</sup> (Table 4). The difference in the time of incorporation of forest litter *i.e.*, at 45 DBS and 30 DBS did not have any significant effect on soil available P. The maximum and minimum available P was recorded in treatments with 9 t ha<sup>-1</sup> of forest litter incorporated at 45 DBS and control, respectively (Table 3). Soil available P increased significantly with each increase in the dose of forest litter application. The application of forest litter @ 3 t ha<sup>-1</sup>, 6 t ha<sup>-1</sup> and 9 t ha<sup>-1</sup> significantly increased the available P at the rate of 7.59, 12.50 and 14.87 %, respectively as compared to control. The accumulation of available P in different treatments due to incorporation of forest litter resulted in a change in P fertility status from low to medium in all the treatments except control. These results corroborate the findings of Ogbodo (2011) and Zhao *et al.*, (2019).

## Available K

The available K in the soil varied from 140.68 kg ha<sup>-1</sup> to 191.83 kg ha<sup>-1</sup> (Table 4). The maximum and minimum available K was recorded in treatments with 9 t ha<sup>-1</sup> of forest litter incorporated at 45 DBS and control, respectively. The difference in the time of incorporation of forest litter *i.e.*, at 45 DBS and 30 DBS did not have any significant effect on soil available K. It was observed that soil available K increased significantly with each increase in the rate of forest litter application. The application of forest litter @ 3 t ha<sup>-1</sup>, 6 t ha<sup>-1</sup> and 9 t ha<sup>-1</sup> significantly increased the available K at the rate of 6.15, 11.77 and 25.92 %, respectively as compared to control (Table 3). The increase in soil available K could be attributed to the release of nutrients on decomposition of organic substrate added through forest litter. These findings are in accordance with the findings of Surekha *et al.*, (2004) and Singh *et al.*, (2006).

In conclusion, the above results established that incorporation of forest litter into the soil prior to sowing had a promising effect on nutrient availability and fertility status of the soil. The early incorporation of the organic litter aided in better decomposition process which increased the level of soil organic matter and subsequently increased the nutrient availability of the soil. Incorporating 9 t ha<sup>-1</sup> of forest litter at 45 DBS had the most beneficial effect on fertility aspects and hence, the most recommendable for practice in farmer's field for improving soil health.

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