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QUANTITY AND QUALITY OF LITTERFALL IN PURE PINE AND PINE/GMELINA MIXED PLANTATIONS IN UMUAHIA, ABIA STATE.

E. C. NZEGBULE, and P. C. OGBONNA

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ABSTRACT

An assessment of the pattern of litterfall and quality of litter were carried out in plantations of pure exotic Pine and Pine/Gmelina mixed plantations at Forestry Research Institute of Nigeria (FRIN) station Umuahia, Abia State. Litterfall was continuous with much of the litter falling between March and April in the pure Pine stand. April 2004 gave significantly ($P<0.05$) the highest litterfall (165.9g/m^2), followed by March 2004 (104.7g/m^2) in pure Pine plantation. In the Pine/Gmelina mixed stand, the highest litterfall occurred in the month of September. The annual litterfall in the pure *Pinus caribea* and pure *Gmelina arborea/Pinus caribea* plantations were 625.12g/m^2 and 450.9g/m^2 respectively. Statistically, no significant difference existed in the mean monthly litterfall in the Pine/Gmelina mixed stand. Also, no significant difference occurred in the mineral content of the plant litters of pure Pine and Pine/Gmelina mixed plantations. Of the two exotic species studied, N (2.03%) and P (0.19%) were more in the litters of pure *Pinus caribea* than in the litters of pure *Pinus caribea/Gmelina arborea* mixed plantation. K (0.9533%), Ca (1.5533%), and Na (0.2033%) were more in the litters of *Pinus caribea/Gmelina arborea* mixed plantation than in the litters of pure *Pinus caribea* plantation. The high litter production of pure Pine stand makes it suitable for soil erosion control. However, mixed plantation of *Gmelina arborea/Pinus caribea* will make better contribution in nutrient-poor soils.

KEY WORDS: Exotic, Pattern, Litterfall, Pine, Pine/Gmelina.

INTRODUCTION

The commencement of litterfall in a forest plantation establishes a major pathway for recycling of nutrients from the plants to soil systems (Bubb *et al.,* 1998). The quantity and nutrient composition of litterfall varies between tree species, stand age and development, and is the result of environmental conditions such as water and nutrient availability (Binkley, 1986; Poglase and Attwill, 1992). Density, basal area, altitude (Reiners and Lang, 1987) latitude (Bray and Gorham, 1964) and season (Luizao and Schubart, 1987) also influences litterfall. Physical disturbances to forest, such as fire and wind storms also induce pulses of litterfall (Bruederle *et al.,* 1985). Of these factors, climate plays a greater role in litter production (John, 1973; Egunjobi, 1974). Litterfall and accumulation are usually continuous through out the year in the tropics, but are often characterized by seasonal peaks (Arunachalam *et al.,* 1998; Okeke and Omaliko, 1994; Muoghalu *et al.,* 1993). There could be a relationship between the time of highest wind speed, associated with the dry season and the time of greatest litter accumulation.

Leaf abscission and leaf senescence also affect leaf litterfall (John, 1973). More so, water stress can trigger synthesis of abscissic acid in foliage of plants that stimulates senescence of leaves and other parts. Defoliating caterpillar (Escudero *et al.,* 1985) and herbivorous insects enhance leaf abscission and leaf litterfall respectively. Climatic, including seasonal variations and other edaphic and physiological factors may affect the pattern and quantity of litterfall produced each year. Although plantations of exotic species have for significant period replaced part of what had existed as a natural forest estate in Nigeria, the pattern of litterfall and litter quality in these plantations particularly in the south eastern part have not been fully investigated. This information will be an indicative of the pattern of litterfall and peculiar characteristics of nutrient flow within these plantations of exotic species.

MATERIALS AND METHODS

Study area

The assessment of the pattern of litterfall was carried out in pure *Pinus caribea* plantation and *Pinus caribea*/*Gmelina arborea* mixed plantation at the Forestry Research Institute of Nigeria (FRIN), Abia State, Nigeria that were established in 1983. The planting distance of the pure *Pinus caribea* was 2.5m x 2.5m and has a monocanopy structure. The mean height of this plantation was 18.2m while the mean diameter-at-breast height was 29.1cm. The *Pinus caribea/Gmelina arborea* mixed plantation has a planting distance of 2m x 2m and multiple canopy structure. The mean height of the mixed plantation was 18.6m while the mean diameter-at-breast height was 27.1cm. Umuahia is within the lowland rainforest zone of Nigeria (Keay, 1959), which lies on latitude 05^{o}29^{1}N and longitude 07^{o}33^{1}E. The area has a mean annual rainfall of 2238mm distributed over eight months of rainy season period (March to October) with bimodal peak in June/July and September. The soil type is ultisol. The minimum and maximum temperature is 23^{o}C and 32^{o}C respectively, and relative humidity of 60–80% (Anon, 2004).

Litterfall collection

Monthly litterfall in the separate stands of pure Pine stand and Pine/Gmelina mixed stand were assessed bi-weekly before composting on a monthly basis for one year (September 2003 – August 2004). The litters were collected with 1m x 1m x 0.2m wooden trays whose bases were covered with 1mm polyethylene sieve. The purpose of litterfall collection was to determine the pattern of litterfall from the various stands. Monthly collections of the litters were initially weighed and bagged, before oven-drying for 5 days at 60^{o}C to constant weight. The samples were digested according to the wet digestion method of Novozamsky *et al.* (1983) for multi-element plant analysis. Calcium in the digest was determined by EDTA titration; potassium and sodium were determined by flame photometry while phosphorus was determined by vanado-molybdate spectrophotometric method. Nitrogen in the digest was determined by micro Kjeldahl distillation method (Bremner and Mulvancy, 1982).

The data on litterfall were analysed for differences between vegetation type and time intervals using analysis of variance (ANOVA), and mean separation by Duncan Multiple Range Test was carried out according to Steel and Torrie, (1980) while the data on mineral composition of plant litters were subjected to T-test.

E. C. Nzegbule, Dept. of Forestry and Environmental Management Michael Okpara Univ. of Agric., Umudike, Abia State, Nigeria.
P. C. Ogbonna, Dept. of Forestry and Environmental Management Michael Okpara Univ. of Agric., Umudike, Abia State, Nigeria.

RESULTS AND DISCUSSION

Pattern of Litterfall

The monthly pattern of litterfall is shown in Figure 1. Although litter fell throughout the year, there was a distinct seasonal trend, with much of the litter falling between March and April particularly in the pure Pine stand. Table 1 shows that March (104.7g/m^2) and April (165.9 g/m^2) had significantly higher litterfall in the pure *Pine* plantation. Egunjobi and Onweluzo (1979), made similar findings that as much as half of the annual total litterfall in a Pine stand occurred during the peak months of February and March at Ibadan, Nigeria. In the study area, the months of March and April are within the dry season characterized with low relative humidity and great fluctuations in diurnal temperatures. The seasonal characteristics probably favoured the increase in litterfall. In the Pine/Gmelina mixed plantation, litterfall slightly peaked between the months of September and October. The heavier rainstorm that promoted dislodgement of more litter materials could explain the increase in Pine/Gmelina litter within these months. However, there were high quantities of litterfall between March and April in the Pine/Gmelina mixed stands. The second peak could be attributed to the litter from the Pine component of the stand structure as it was also observed to have peaked within these months for the pure Pine stand. From Fig. 1, the pattern of litterfall in the 2 plantations were different. This difference is attributed to the species composition of the plantations which influences both pattern of fall and characteristics of litter (Binkley, 1986; Polglase and Attiwill, 1992). The influence of locational difference is ruled out in this assessment since both stands were located adjacent to each other (Bray and Gorham, 1964). The mean annual litterfall in the pure Pine and Pine/Gmelina stands were 36g/m^2 and 52.1g/m^2 respectively and they were significantly different. Evergreen vegetation such as Pine produced more litter than deciduous vegetation (Vogt *et al.,* 1986; Bray and Gorham, 1964). The evergreen species in the Pine stand had higher litterfall than the Pine/Gmelina mixed stand.

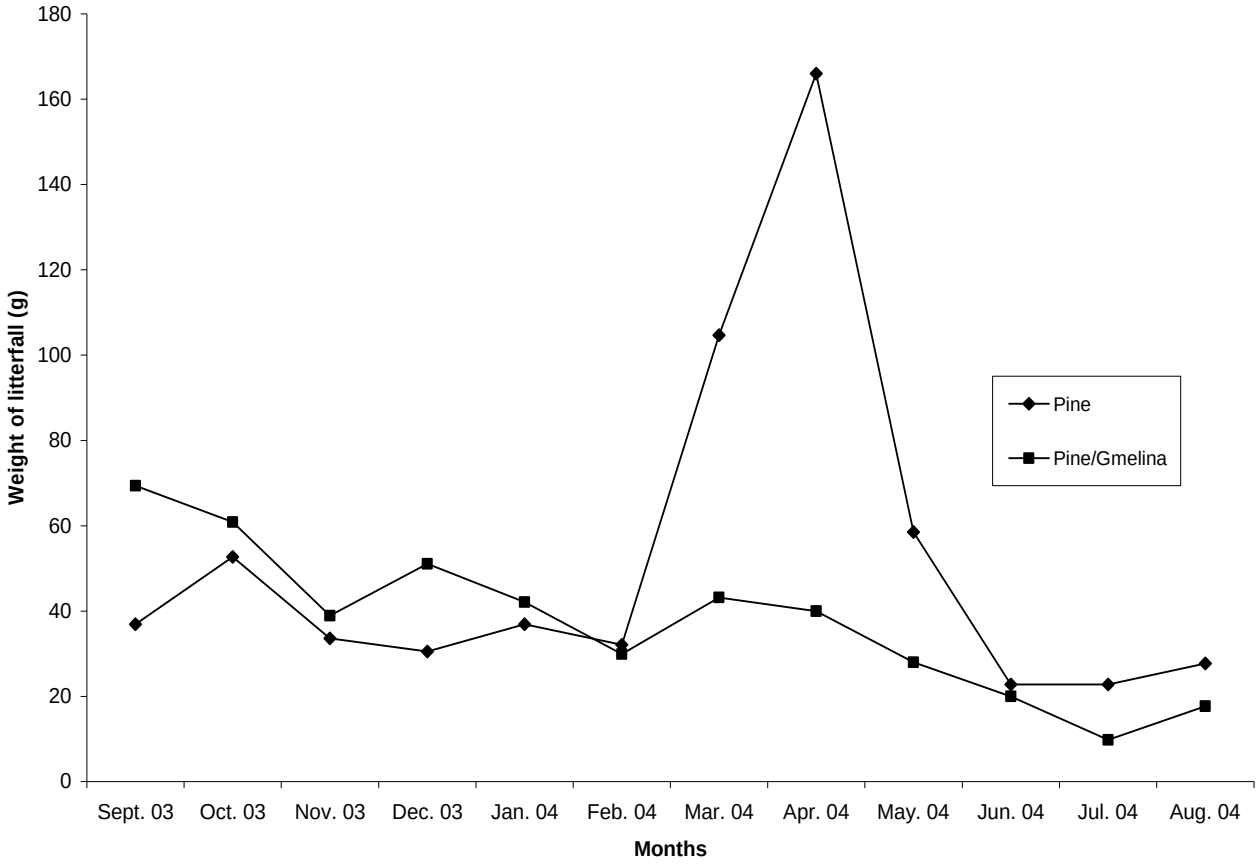

Fig. 1: Monthly variations of litterfall in pure Pine and Pine/Gmelina plantations in Umuahia.

Table 1: Seasonal litterfall (g/m^2) in pure Pine and Pine/Gmelina mixed plantations at Umuahia.

Vegetation type	Dry season November - March	Wet season April - October	Annual total
Pine	237.85	387.25	625.1^x
Pine/Gmelina	205.17	245.73	450.9^y

Litter Quality

The mineral content of plant litters in the two plantations is not similar (Table 2). However, there was no significant difference between the mineral content of the pure Pine and Pine/Gmelina mixed plantations. Of the two exotic species studied, N (2.03%) and P (0.19%) were more in the litters of pure *Pinus caribea* than in the litters of *Pinus caribea/Gmelina arborea* mixed plantation. Pine species attracts mycorrhizal association that promotes greater availability of nitrogen (N), Phosphorus (P) and Magnesium (Mg) in land uses where it dominates (Melin, 1962; Stone and McAuliffe, 1954). K (0.9533%) and Ca (1.5533%) were more in the litters of *Pinus caribea/Gmelina arborea* mixed plantation than in the litters of pure *Pinus caribea* plantation. The higher Ca in the mixed plantation (*Pinus caribea/Gmelina arborea*) could be attributed to the litters of *Gmelina arborea*. This agreed with findings of Sachez *et al.,* (1985) that Ca is higher under plantation of *Gmelina arborea* than under Pine plantation. Differences in soil, age and composition of the vegetation could alter the quantities of major plant nutrients in plant litter (Kadeba and Aduayi, 1985).

Table 2: Mineral composition of plant litters in the pure *Pinus caribea* and *Pinus caribea/Gmelina* plantations.

Stand	Nutrient Element					
	%K	%Na	%P	%N	%Ca	%Mg
Pine	0.2500	0.1933	0.1900	2.0300	1.3000	0.5267
Pine/Gmelina	0.9533	0.2033	0.1433	1.2367	1.5533	0.4467
Std error (s.e.d)	0.2997	0.0313	0.0176	0.4731	0.7688	0.3071
Sig.	ns	ns	ns	ns	ns	ns

ns = no significant difference at ($p<0.05$)

CONCLUSION

The months of March and April period, which is in the dry season period with low relative humidity and great fluctuations in diurnal temperatures, had higher litterfall (104 g/m^2 and 165.9 g/m^2 respectively) than other months of the year in the Pine stand. Also, the pure Pine stand produced more litter per annum (625.1g/m^2) than Pine/Gmelina mixed plantation (450.9 g/m^2). The Pine plantation with higher trend of litterfall is a good plant species to be established on sites that could be vulnerable to soil and wind erosion. The high accumulation of Pine litters on the plantation floor along side with the stems greatly reduces the speed of run-off thus, minimizing the incidence of soil erosion. However, the Pine/Gmelina mixed plantation had higher content of base elements (K, Ca, Na and P) that could be useful in rehabilitating nutrient poor soils.

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