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Effect of eucalyptus (*Eucalyptus camaldulensis*) and maize (*Zea mays*) litter on growth, development, mycorrhizal colonization and roots nodulation of *Arachis hypogaea*

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In Senegal, farmers often cultivate groundnut in association with eucalyptus plantations to increase their incomes. However eucalyptus plantations produce large amounts of litter, which impact on groundnut has not been clearly elucidated yet. In order to investigate litter accumulation effect on growth, development, and groundnut root infection by arbuscular mycorrhizal fungi (AMF) and rhizobia, a greenhouse experiment was performed. The effect of eucalyptus litter was compared to that maize litter effect at three litter amendments (0, 1 and 5%). Chemical analysis showed that eucalyptus litter differed essentially from maize litter by its high polyphenols content and lower pH. At high amendment (5%), root nodulation and mycorrhizal colonization were significantly reduced with eucalyptus litter whereas no significant differences were observed with maize litter. In addition, groundnut growth, number of flowers per plant, pods yield and leaf mineral contents (N and C) were significantly lower for plant grown in soil highly amended with eucalyptus litter. Plants showed deficiency of chlorophyll content in leaves and were less vigorous compared to treatments without amendment and those amended at 1% level. For all parameters measured, plants grown in soil lowly amended (1%) and plants grown in control treatment did not significantly differ.

Key words: Litter, *Eucalyptus*, *Arachis hypogaea*, *Mycorrhizal* symbiosis, *Rhizobia*.

INTRODUCTION

The agricultural development efforts in Senegal particularly focused on groundnut production, which strongly contributes to Senegal's economy. Groundnut is most of

the time grown in rotation and/or association with non-legumes (millet, maize, sorghum) because the legume and bacteria form a symbiosis in nitrogen fixation, therefore sustaining nitrogen, the main limiting nutrient to the succeeding crops.

However the drought of 1970s has considerably decreased farmers' incomes. In order to offset this loss of income, farmers had chosen eucalyptus as an alternative crop in their arable area. Indeed, eucalyptus wood is an

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important source of building material (Eldridge et al., 1993) and the sale of eucalyptus poles and products has the potential to raise farm incomes, reducing poverty (Anonymous, 2010).

Therefore, groundnut which is historically dominant is now found intercropping within *Eucalyptus camaldulensis* plantations. This agroforestry system, although highly recommended for the indigenous species, may impose unforeseen consequences. Eucalyptus as an industrial crop which is non-edible occupies agricultural land intended for food crops cultivation; and may negatively affect native plant species (including crops). Also, eucalyptus can compete with crops underlying light, water and soil nutrient (Onyewotu et al., 1994; Pérez Bidegain et al., 2001) or by changing the soil pH (Kubmarawa et al., 2008; Mubarak et al., 2011).

In addition, eucalyptus produces allelopathic compounds (that is, production of phytochemical inhibitors) that may adversely affect crop productivity (Lima, 1987). Allelopathy may act directly to plants (Fjeldså and Kessler, 2004 in Gareca et al., 2007; Callaway, 2004) or indirectly on the soils microbial component particularly on the arbuscular mycorrhizal fungi (AMF) (Stinson et al., 2006) and rhizobia, legume symbionts (Le Mer and Roger, 2001; Faye et al., 2009; Sanon et al., 2009).

It is well established that legume such as groundnut plant depends strongly on symbiosis for growth and production (Lindemann and Glover, 2003; Piotrowski et al., 2008; Vieira et al., 2010). Arbuscular mycorrhizal fungi improve plant mineral nutrition especially phosphorus and nitrogen (Smith and Read, 2008; Javaid, 2009), while, rhizobia improve plants nitrogen nutrition (van der Heijden et al., 2006). Tree-culture association is beneficial and sustainable if, positive effects of the tree productivity, sustainability are greater than the adverse effects (reduction of cultivated areas, shade, competition, allelopathy).

So far, little is known about eucalyptus effects on groundnut (growth and yield) and roots symbiotic partners (AMF and *Rhizobia*) mainly in Senegal. To address this knowledge gap, we studied the impact of two levels of eucalyptus litter in comparison to maize litter on groundnut development and production in a greenhouse experiment. This experiment will contribute to an understanding on the effect of litter accumulation on groundnut production in greenhouse conditions. In addition, the findings from this study could be useful to predict the potential hazards of *Eucalyptus*-groundnut association.

MATERIALS AND METHODS

Chemical analysis of litters

Eucalyptus litter was collected under the shade of old eucalyptus trees (12 years old), and was composed of dead leaves, bark, fruits, twigs and seeds, while maize litter consisted of crop residues (leaves and stems). Before chemical analysis, the litters were ground and sieved (2 mm). Total C, total N and total P in litters were measured, in the LAMA laboratory (Certified ISO 9001,

version 2008, Dakar, Senegal; Institut de Recherche pour le Développement [www.lama.ird.sn]. Phenolic compounds were extracted by soaking 1 g of powder in 100 ml of acetone 80% (v/v). The extraction was performed under ultrasound for 30 min at 4°C to prevent the action of polyphenoloxidase which can degrade phenolic compounds. The phenolic content was determined following Folin-Ciocalteu method using Gallic acid as standard range (Singleton and Rossi, 1965). The absorbance reading was performed by using ultraviolet (UV)-visible spectrophotometer (Ultrospec 3000 / Pharmacia Biotech France) at $\lambda = 760$. Results were expressed as mg/g gallic acid equivalent.

Greenhouse experiment

The litter effects on groundnuts were determined in a pot experiment using an unsterilized soil collected from Sangalkam, Senegal (14°46'52"N, 17°13'40"W). The soil physicochemical characteristics were as follows: pH (H₂O), 7.02; clay, 8.7%; silt, 5.80%; sand, 88.80%; carbon, 0.30%; total nitrogen, 0.02%; soluble phosphorus, 2.1 mg kg⁻¹ and total phosphorus, 41.4 mg kg⁻¹. Each litter was separately mixed with the soil to make two doses: 5% (w of litter/w of soil) and 1% (w/w). For each soil-litter mixture, 500 g were placed into a 500 ml polyethylene pot. Five treatments were obtained of which 2 (EH (5%), EL (1%)) for eucalyptus litter, 2 (MH(5%), ML (1%)) for maize litter and one without litter amendment (T). ML and EL were considered as low amendment treatments, while EH and MH were considered as high amendment treatments. Six replicates were per-formed for each treatment and arranged in a randomized complete block design.

Two groundnuts seeds (variety hasty 55 to 437; 90 days) were sown in each pot and a week after weeding was performed to maintain one plant per pot. Plants were grown under natural light (daylight approximately 12 h, mean day-time temperature 35°C) and watered daily with tap water during three months.

Flowering survey

The onset of flowering and the number of new flowers were documented every two days during 18 days, duration of flowering process (Catan and Fleury, 1998).

Leaves chlorophyll content

45 days after sowing, the same weight of leaves (2 g) was harvested from plants of each treatment and leaves chlorophyll content were assessed using the method described by Arnon et al. (1949). A weight of 100 mg of ground fresh leaves was suspended in an 80% acetone buffer (80 ml of acetone made up to 100 ml of 2.5 mM sodium phosphate buffer (pH 7.8)) and the mixture was incubated at 4°C overnight in dark. Supernatant was withdrawn after centrifugation (10,000 g; rotor Nr 12154, Sigma 3K15, USA) and absorbance of aqueous extract was recorded at 662 nm with a spectrophotometer (Ultrospec 3000/Pharmacia Biotech France). Total chlorophyll content was determined by the formula:

$$\text{Chl} = A_{662} \times 27.8 \text{ mg/L/g.fresh material} \quad (A_{662} = \text{absorbance at } 662 \text{ nm}) \text{ (Arnon et al., 1949).}$$

Mycorrhizal infection and nodulation

At the end of experiment (after three months), plants were harvested and AM colonization was assessed according to the method of Phillips and Hayman (1970). Fine roots were collected from plants, washed with tap water, cleared in 10% KOH and stained with

0.05% trypan blue. They were subsequently placed on slides for microscopic observations at 250 × magnifications (Brundett et al., 1996). Five slides, each with ten randomly selected stained roots (approximately 1.5 cm long root pieces) were prepared for each treatment. Mycorrhizal colonization (intensity of roots colonization), the number and dry weight (60°C, one week) of nodules were determined.

Shoots, roots dry matter and nutrient content in shoots

Shoots and roots of each plant were separated, dried (60°C, one week) and weighed. After drying, shoots were ground and 1 g of powder from each plant was washed (500°C), digested in 2 ml HCl 6 N and 10 ml HNO₃ N and then analyzed by colorimetry for P (John, 1970). Total nitrogen and carbon were measured by dry combustion with a CHN analyzer (LECO Corporation, St. Joseph, MI, USA).

Statistical analysis

All measured variables were subjected to a one-way analysis of variance (ANOVA) to assess differences between the treatments. Principal component analysis (PCA) was used to highlight the relationship between treatments and variables. Statistical analyses were performed using Xlstat software 2010 for ANOVA and R software (version R-2.13.0) for PCA.

RESULTS

Discrimination treatments based on plants growth parameters (principal components analysis)

The horizontal axis on the PCA (PCA 1) is strongly correlated to shoots and roots dry matter, groundnuts pod, total C, total N and chlorophyll content, while vertical axis PCA 2 is correlated to shoots phosphorus contents (P). This PCA explaining 83.74% of the variability in the first two factors discriminated the treatments according to the type of litter (maize versus eucalyptus) and quantity added to soil (high versus low) (Figure 1). For instance, the treatment, EH was relatively far away from the treatment MH on the PCA 1 (explaining 57.46% of the variability), whereas the treatment MH was relatively far away from the treatment ML on the PCA 2. Indeed, the plants raised on the soil highly amended with eucalyptus litter (EH) had the highest levels of total phosphorus in the shoots, lowest growth and lowest pod yields (Table 1). In contrast, the plants were raised on the treatments MH, ML and T had the highest C and N contents in shoots. The plants from the treatment EL displayed intermediate position between EH and others treatments. Control, ML and MH treatments presented higher pod yield, nodule, roots and shoots dry matter. Also, more root colonization was recorded for control, ML and MH treatments in comparison to the treatments amended with eucalyptus litter (EL and EH) (Figure 1).

Effect of litters on growth, leaves chlorophyll and shoots mineral content of *Arachis hypogaea*

The plants grown in the treatments T, MH and ML flourished earlier (35, 35 and 37 days after sowing, respec-

tively), followed by the plants grown in the treatment EL (41 days after sowing) and the plants grown in the treatment EH (49 days after sowing). Therefore, the plants grown in the treatment EL displayed a six days delay of flowering and those grown in the treatment EH displayed a 14 days delay of flowering. Moreover, the plants grown in the treatment T produced more flowers than the others plants, during the measurement period (Figure 2).

In contrast, plants of the treatment EH had yellow leaves and less vegetative development compared to other treatments (data not shown) for the duration of the experiment. This is supported by the significant low chlorophyll content for EH treated plant as compared to others (Table 2). Chlorophyll content in leaves were positively and very significantly correlated with yield of pods, shoots and roots dry weight (0.68^{***}, 0.57^{**} and 0.47^{**} respectively) (Table 3) suggesting that yield and good development of plant could be related with leaves chlorophyll content.

N and C contents in *Arachis hypogaea* shoots were significantly lower in shoots of plants grown at 5% level amendment of eucalyptus litter compared to the other treatments (Table 2). No significant difference was found between the control and the low amended soil with the different residues. However, it is noteworthy that highest P shoots contents were found with the 5% treatment (EH and MH as already shown in PCA). Significant positive correlations were recorded between N and C leaves contents and chlorophyll contents (0.90^{***} and 0.55^{**}). These elements were also significantly correlated with AM colonization (0.65^{***} and 0.55^{***} respectively) and nodules dry weight (0.75^{**} and 0.86^{***}) (Table 3) suggesting an improvement of mineral nutrition by these symbiosis.

Mycorrhizal infection and nodulation

Mycorrhizal infection was greatly reduced in EH treatment. Also, nodulation infectivity (number and dry weight of nodule) was delayed for this treatment (Table 1). However, mycorrhization and nodulation were not significantly different for others treatments (EL, ML and MH). Mycorrhizal intensity was positively and significantly correlated with yield of pods, shoots and roots dry weight (0.73^{***}, 0.60^{***} and 0.53^{**} respectively). In addition, nodules weight were positively correlated to the yield of pods, shoots and roots dry weight (0.37^{*}, 0.85^{***} and 0.38^{*} respectively) (Table 3), this suggesting that mycorrhizal infection and nodulation were inhibited by high level of eucalyptus litter.

Chemical characteristics of the litter materials

Carbon, total polyphenols content were higher in eucalyptus litter compared to maize litter (Table 4). In addition, pH was lower for eucalyptus litter. However, there were no significant differences in N and P contents between

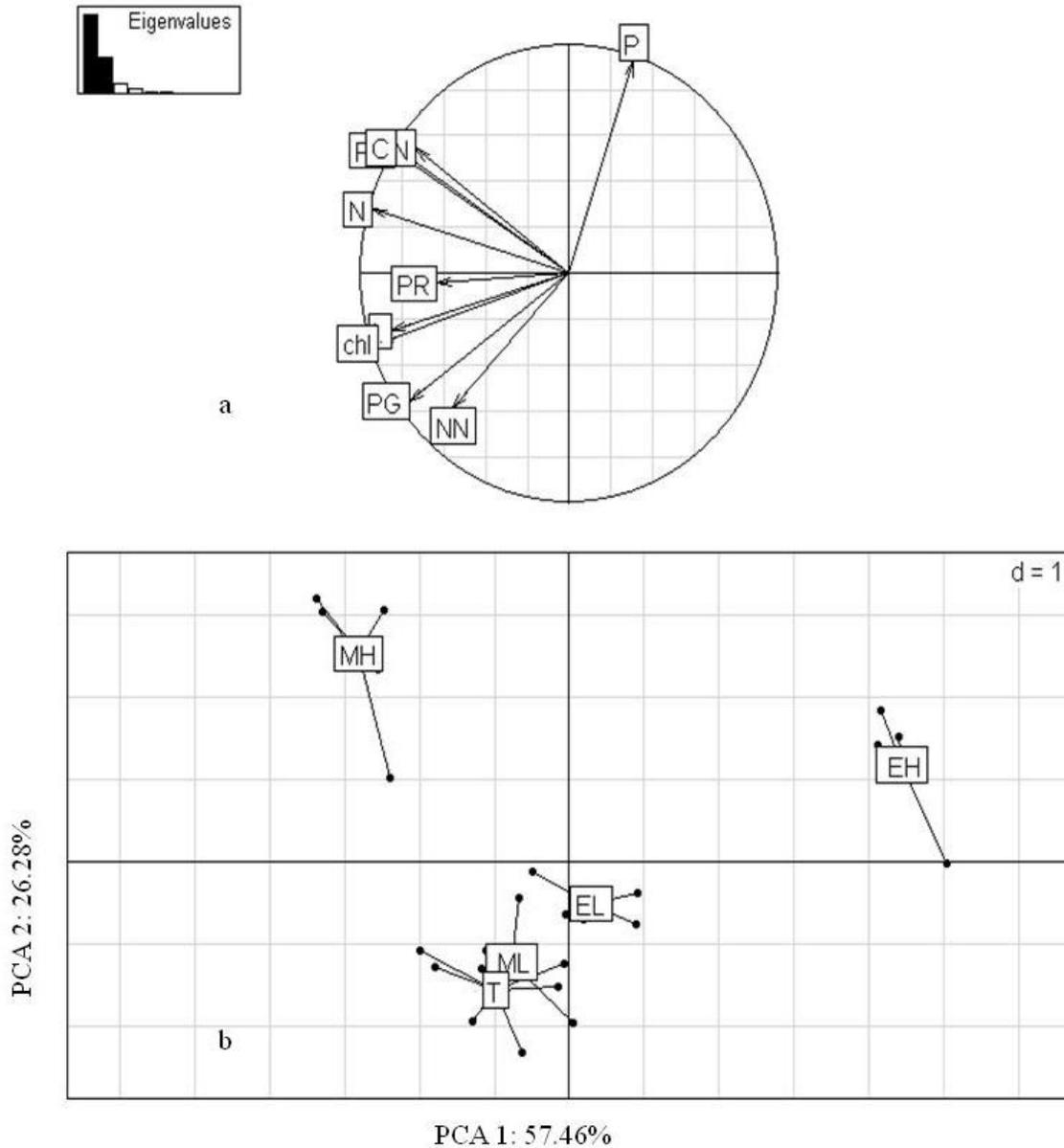


Figure 1. Principal component analysis, biplot depicting the relations between treatments and variables. PA, PR, PG, PN, NN, Chl, N, P, C, I% as the same in Table 3. EH and EL, are respectively high (5%) and low (1%) amended soil with eucalyptus litter; MH and ML are high (5%) and low (1%) amended soil with maize litter; T, control without amendment.

Table 1. Growth response, nodulation, AM colonization and yield pods *A. hypogea* seedlings grown in soil with different treatments.

Treatment	EL	EH	ML	MH	T
Shoots biomass (g dry weight)	1.279 ^b	0.887 ^c	1.339 ^b	2.446 ^a	1.458 ^b
Roots biomass (g dry weight)	0.775 ^a	0.307 ^b	0.766 ^a	0.740 ^a	0.581 ^{ab}
yield of groundnut pods	1.105 ^b	0.000 ^c	1.386 ^{ab}	1.176 ^b	1.711 ^a
Nodule biomass (g dry weight)	0.045 ^b	0.000 ^c	0.050 ^b	0.183 ^a	0.051 ^b
Nodule number	51.833 ^b	0.000 ^c	60.000 ^{ab}	42.200 ^{bc}	110.000 ^a
AM (%)	31.600 ^b	11.017 ^c	53.100 ^a	48.720 ^a	45.400 ^{ab}

Data in the column followed by the same letter are not significantly different according to Newman–Keuls test ($p < 0.05$). EH and EL, are respectively high (5%) and low (1%) amended soil with eucalyptus litter; MH and ML are high (5%) and low (1%) amended soil with maize litter; T, control without amendment.

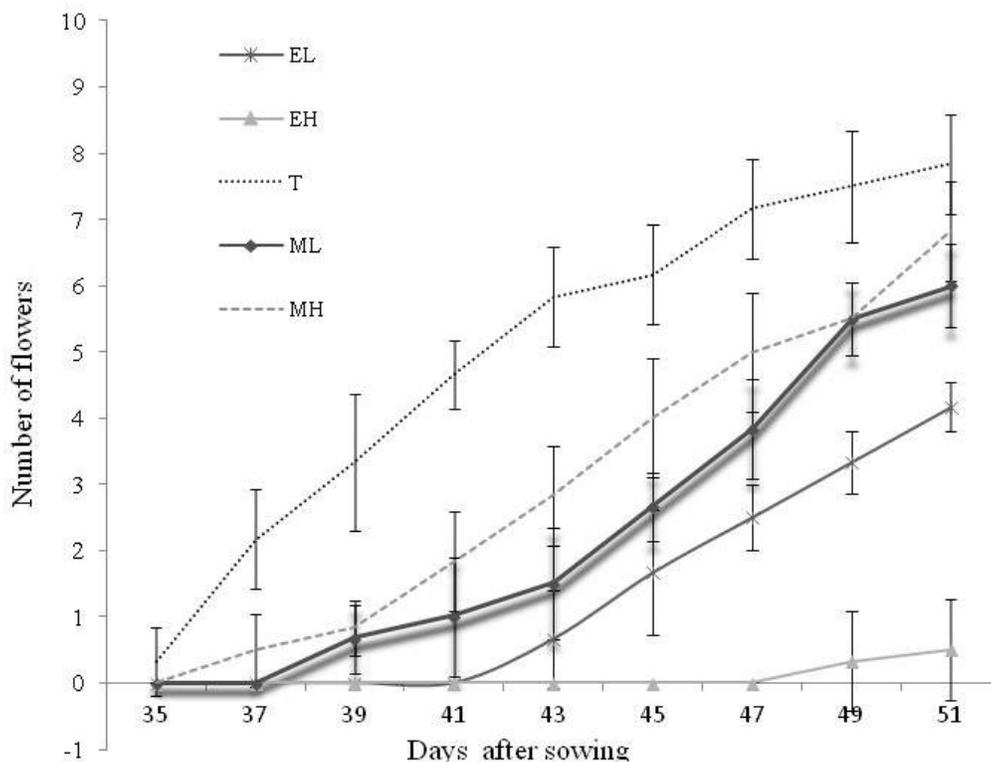


Figure 2. Flower production on branches of groundnut plants. Bars indicate standard deviation to the mean of six repetitions. EH and EL, are respectively high (5%) and low (1%) amended soil with eucalyptus litter; MH and ML are high (5%) and low (1%) amended soil with maize litter; T, control without amendment.

Table 2. Leaves chlorophyll and shoots mineral content of *A. hypogea* seedlings grown in soil with different treatments.

Treatment	EL	EH	ML	MH	T
Chl (mg/l/gMF)	1.655 ^a	0.460 ^b	1.925 ^a	1.944 ^a	1.808 ^a
C (mg per plant)	464.728 ^b	262.595 ^c	496.188 ^b	889.756 ^a	526.278 ^b
N (mg per plant)	17.264 ^b	8.874 ^c	18.181 ^b	26.176 ^a	18.808 ^b
P (mg per plant)	1.752 ^b	3.789 ^a	1.063 ^b	3.523 ^a	1.006 ^b

Data in the column followed by the same letter are not significantly different according to Newman-Keuls test ($P < 0.05$).

EH and EL, are respectively high (5%) and low (1%) amended soil with eucalyptus litter; MH and ML are high (5%) and low (1%) amended soil with maize litter; T, control without amendment.

Table 3. Correlation analysis between different variables measured in treatments

Variable	PA	PR	PG	PN	NN	N (mg/plant)	P (mg/plant)	C (mg/plant)	I%
PR	0.57**								
PG	0.53**	0.56**							
PN	0.85***	0.38*	0.37*						
NN	0.37	0.31*	0.71***	0.35*					
N (mg per plant)	0.93***	0.68***	0.70***	0.75**	0.52***				
P (mg per plant)	-0.02 ns	-0.32 ns	-0.73 ***	0.000ns	-0.65***	-0.27ns			
C (mg per plant)	0.98***	0.52**	0.48**	0.86***	0.35**	0.90***	0.01ns		
I%	0.59***	0.53**	0.72***	0.50**	0.50**	0.65***	-0.40 ns	0.55***	
chl (mg/l/gMF)	0.57**	0.47**	0.68***	0.38*	0.44*	0.63***	-0.39 ns	0.55**	0.69***

PA, shoots biomass; PR, roots dry weight; PG, yield of groundnuts pods; PN, nodule biomass; Chl, leaf chlorophyll content; NN, number of nodule; I%, mycorrhizal intensity; ns, not significant. * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

Table 4. Litter chemical characteristics.

Characteristic	Carbon (%)	Nitrogen (%)	C/N	P total (g/kg)	pH	Total polyphenol
Eucalyptus litter	45.67 ± 2.0 ^a	0.8 ± 0.2 ^a	51.71	1.3 ± 0.3 ^a	5.1 ± 0.1 ^b	40.6 ± 1.40 ^a
Maize litter	37.47 ± 1.7 ^b	0.7 ± 0.1 ^a	53.5	1.06 ± 0.2 ^a	6.1 ± 0.1 ^a	4.3 ± 0.79 ^b

Data in the same column followed by the same letter are not significantly different according to the one-way ANOVA ($P < 0.05$). Means reported with standard errors.

Table 5. Correlation analysis between different variables measured and litters chemical (pH and phenol).

Variable	Total polyphenol	pH
PA	-0.68*	0.70*
PR	-0.82**	0.63*
PG	-0.91***	0.56 ^{ns}
PN	-0.51 ^{ns}	0.57 ^{ns}
NN	-0.81***	0.69*
N (mg per plant)	-0.84 ^{ns}	0.79**
P (mg per plant)	0.56 ^{ns}	-0.31 ^{ns}
C (mg per plant)	-0.67*	0.71*
I%	-0.84**	0.85***
Chl (mg/l/g MF)	-0.986***	0.74**

PA, shoots dry weight; PR, roots dry weight; PG, yield of groundnuts pods; PN, nodule dry weight; Chl, leaf chlorophyll content; NN, number of nodule; I%, mycorrhizal intensity, ns, not significant. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Table 6. Soil pH after harvest.

Treatment	EL	EH	T	MH	ML
pH	6.44 ^b	5.54 ^c	7.52 ^a	7.34 ^a	7.15 ^a

Data in the same line followed by the same letter are not significantly different according to the one-way analysis of variance ($p < 0.05$). EH and EL, are respectively high (5%) and low (1%) amended soil with eucalyptus litter; MH and ML are high (5%) and low (1%) amended soil with maize litter; T, control without amendment.

between these two different litters (Table 1). Litters C/N ratio were almost identical. The amount of phenols added to each treatment was determined (data not shown) and the correlation was established between the amounts of phenols from soil and growth variables (Table 5). Similarly, correlation of these variables and soil pH after amendment (data not show) were determined (Table 5). Polyphenols were negatively linked to growth variables (except for P), while most of these variables were positively correlated with pH (Table 5). Soil pH remained acidic for treatments amended with eucalyptus litter while control treatment amended and unamended were neutral (Table 6). Difference in polyphenols and pH will mainly lead results discussion.

DISCUSSION

An amendment is an addition of organic matter in soil. The chemical quality of this organic matter strongly influ-

ences plant growth. Our experiment shows that at high dose, eucalyptus litter reduced plant flowers (and early flowering), growth and production, probably through its acidity and very high level of phenol compounds (as evidence by negative correlation between variables growth and these two parameters). Soil acidity decrease roots growth and soil explored by roots and therefore a decrease of mineral absorption for plant growth. Many authors (Koyama et al., 2001; Hopkinsa et al., 2004; Pavlovkin et al., 2009) have shown that plants exposed to low pH stress are normally subjected to metal toxicity, and hence decrease in the root growth and the total biomass.

Acidity significantly reduces mineral absorption by plants (James and Nelson, 1981). Low total C and N content in shoots of EH treated plants seem in agreement with this hypothesis.

Lowest chlorophyll content in leaves and flowering retardation of plants for the treatment EH compared to

other treatments (ML, MH, EL and T) is probably a consequence of this nutritional imbalance. This inhibition can severely compromise groundnut yield (Catan and Fleury, 1998) especially in Sahelian countries where rainy season would only last for three months.

Maize litter does not affect *A. hypogaea* growth in low and high amendment treatments (ML and MH). This means that maize litter did not significantly modify soil chemical properties (pH and phenol content) as compared to control. Also, *A. hypogaea* plants were tolerant to 1% eucalyptus amendment dose since they showed no significant growth change as compared to control.

At high litter amendment (5%), eucalyptus reduced drastically *A. hypogaea* height (not shown) shoots dry matter and pods yield, suggesting that accumulating of eucalyptus residues in time could reduce plant growth and crops production in intercropping systems.

Our study corroborates Suresh and Rai (1987) studies which showed a strong reduction of seeds germination, root length and dry matter production of sorghum, cowpea (*Vigna unguiculata*) and sunflower in cultivating with *Eucalyptus tereticornis*, *Casuarina equisetifolia* and *Leucaena leucocephala*. Using extract from leaves and bark of *E. tereticornis*, Puri and Khara (1991) observed similar results on *Phaseous vulgaris* germination and total biomass.

The depressive effect of acidity and phenols on growth of *A. hypogaea* can be done indirectly by reducing or canceling symbiotic microorganism contribution on plant growth. Our work showed a positive correlation between AM mycorrhizal and growth parameters [shoots dry weight (PA); roots dry weight (PR), yield of groundnuts pods (PG)] and shoots mineral contents (N and C). This suggests that AM fungi promote plant development by increasing nutrient use occurred with increasing AM fungi hyphal. Many publications have already shown that mycorrhizal symbiosis increases nitrogen uptake from the soil (Barea et al., 1991), plant fitness and nutrient turnover (Jeffries et al., 2003). However, at high eucalyptus litter amendment (5%), our results showed that mycorrhizal formation and mineral leaves contents were strongly reduced (low AM colonization, low N and C contents, and cancel nodulation). According to Lehto (1994), soil pH affects the ability of roots to grow or ability of mycorrhizal fungi to colonize roots and to take up nutrients. Also in our study, the high polyphenol content in eucalyptus organic matter could accentuate the negative effect by reducing germination, hyphal extension (Cantor et al., 2011) or killing symbiotic, partner of *A. hypogaea*, or preventing the mechanism to recognition in symbiotic partners. Callaway et al. (2008) had already suggested that potential allelopathic effects of exotic species (*Alliaria petiolata*) might be due to direct inhibition of plant seedlings and fungus before the formation of symbiosis.

It has already been well established that some alien species negatively impact (inhibit, delete, reduce abun-

dance and performance of N-fixing microbes) on nodulation through their organic residues or aqueous root extract (Faye et al., 2009; Sanon et al., 2009). Poore and Fries, 1985 found that germination and growth of associated species was inhibited by extracts of eucalyptus leaves. Several physiological reasons have been attributed to this phenomenon including: inhibition of infection of leguminous roots by nodule bacteria leading to decreasing nodule formation; inhibition of nitrogenase enzyme activity in the nodule due to modification of the nitrogenase iron protein and decrease in the supply of photosynthates to the rhizobium due to the poor supply of major nutrients, such as P (Bolan et al., 2003). Our results on groundnuts are not necessarily generalizable to all plants. In fact some plants not symbiotically dependent or having co-evolved with eucalyptus may not be affected by eucalyptus litter (Alliaume et al., 2010). In addition, some authors (Sarkar et al., 2010) have already observed positive impact of eucalyptus amendment on the growth of red amaranth.

Phosphorus, the major nutrient most needed by groundnuts has a vital role in energy storage, root development and early maturity of crops. The highest phosphorus concentration observed in plants amended with 5% of eucalyptus organic matter seems to be linked to the lack of groundnuts pods. This allows us to conclude that, in other treatments, great part of phosphorus is used for groundnuts pods production. This result is in accordance with previous studies which showed that, in Senegal 65% of the phosphorus taken up by the crops is stored in pods and hence removed from the field at harvest (Schilling et al., 1996).

The young eucalyptus is associated with AMF while adult plants are associated with ectomycorrhizal fungi (ECMF) (Malajczuk et al., 1982). Our study allows us to formulate a hypothesis on the mycorrhizal successional allegedly linked to the accumulation of organic matter, specifically polyphenols associated with the organic matter. In fact, it was already demonstrated some ECMF could detoxify phenolics while AMF cannot and were inhibited with increasing soil polyphenols concentration. Therefore phenols increasing reduce AM roots colonization in aid of ECM colonization (Piotrowski et al., 2008).

Conclusion

Maize and Eucalyptus litter are differentiated mainly by their pH and polyphenols content. This work shows that high dose of Eucalyptus litter caused depressive effects on growth and yield of groundnut. Mycorrhizal colonization and root nodule formation were also strongly reduced for plant grown in soil highly amended with eucalyptus litter. This work supports the idea that planting *A. hypogaea* in association with *Eucalyptus* plantation may be against production in the long term due to the accumulation of eucalyptus residues. In future studies, it will be

necessary to clarify whether it is the action of pH or polyphenols that is responsible for adverse effect or the synergy of both. Whatever concentration, maize litter doesn't show any depressive effects on groundnuts growth and production.

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