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# RESPONSES OF MAIZE SEED GERMINATION AND PLANT GROWTH TO AMENDMENTS OF MIXED LEAF POWDERS OF THREE MULTIPURPOSE PLANT SPECIES IN SUDANO-GUINEA SAVANNAS OF NGAOUNDERE, CAMEROON

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***Abstract:*** *In order to contribute of introducing indigenous plant species in soil fertility management, trials were conducted in pot and field at the University of Ngaoundéré to study the effect of mixed leaf powders of Tithonia diversifolia, Terminalia glaucescens and Annona senegalensis on seed germination and plant growth of maize. Leaf powder samples were mixed with 0.5 kg of soil in pots at three doses (10, 20 and 30 g). For the plant growth, field experiments were carried out in 4 m x 1 m plots each. The results showed that the powders of the three plant species and their mixtures did not show toxic effects on seed germination at all three doses. For all treatments and at all doses, the germination rate reached 100% at 12 DAS, with the exception of the control (80% of germination) and the three mixtures (AS+TD, AS+TG and AS+TD+TG) at the high dose (30g). Growth parameters and plant biomass for all treatments were significantly (p< 0,001) higher than those of control, and the best amendment was the powder mixture of A. senegalensis and T. glaucescens, with height value of 103.07 cm, leaf number of 14.33, neck diameter of 14.49 mm, and biomass of 98.57g. Compared to the control, all treatments improved the soil C, N and P contents, and the best improvement provided by the mixture of leaf powders of A. senegalensis and T. glaucescens. The three plant species leaf and their mixture under the conditions of these trials have been of great potential for improving the availability of soil nutrients by providing the quantity necessary for cultivation of maize without addition of chemical fertilizers. These results would contribute to the agroforestry plant species choice to domesticate for management of soil fertility of the Ngaoundere savannahs of Cameroon in particular and those of Sudano-guinea savannahs in general..*

***Key words:*** *Leaf powders, seed germination, plant growth, phytotoxicity, maize, sudano-guinea savannah.*

## INTRODUCTION

In the Sudano-guinean savannas of Ngaoundere, human activities such as extensive agriculture, logging, overgrazing and bush fires, due to population growth, lead to the degradation of natural ecosystems (RANAVA ET AL., 2016; NYASIRI ET AL., 218). The consequences of these activities translate into an increase in the surface of erodible soils (POMEL ET AL., 1994), a rapid depletion of nutrients, particularly nitrogen and phosphorus (KAHO ET AL., 2007; YEMEFACK ET AL. ., 2006), etc., thus leading to falling yields of major food crops and food insecurity (FAO, 2016). For example, the reduction of the fallow period from six to less than two years in the humid savannah zone in Nigeria and Benin led to cassava yield reductions from 11 $t.ha^{-1}$ to less than 2 $t.ha^{-1}$ **(**SANGINGA ET AL., 1990**)**. In terms of soil quality, the intensification of crops always leads to a drop in the level of soil fertility and their most apparent negative effects are the reduction in the rate of organic matter associated with the reduction in the quantity of nitrogen in the soil, the soil and the invasion of cultivated land by weeds (AHUJA, 2003). In addition, the majority of farmers overuse chemical fertilizers, which unfortunately have drawbacks such as high cost, environmental pollution and lower production in the long term (AHUJA, 2003; BADO, 2002). Organic fertilizers alone are insufficient to compensate for the low level of nutrients in tropical soils (MUNA-MUCHERU ET AL., 2007; UYOYBESERE AND ELEMO, 2000). Organic fertilizers, due to their beneficial effects on the physico-chemical and biological properties of the soil, and therefore on plant growth, would make it possible to make the use of modest doses of mineral fertilizers more effective (JAMA ET AL., 2000; UYOYBESERE AND ELEMO, 2000). However, the success of this strategy will depend on the quality of the organic material used and the amount of nutrients contained in this material (PALM, 1995).

To overcome the problems of soil degradation and improve their fertility, it is therefore necessary to develop and promote appropriate alternative technologies such as agroforestry, which is little practiced by farmers in this region. This involves introducing or maintaining in production systems trees that contribute to the improvement or restoration of soil fertility, by fixing atmospheric nitrogen and through the leaves or litter whose decomposition and mineralization release the organic compounds and nutrients necessary for soil fertility and the biological activity into the soil (IBRAHIMA ET AL., 2002). For this, a number of works on agroforestry species with potential to improve soil fertility in Cameroon have focused mainly on nitrogen-fixing leguminous (DUGUMA AND MOLLET, 1997; KAHO ET AL., 2007; KAHO ET AL., 2004; KANMEGNE ET AL., 1999) and on litter (FODEUBA, 2009; MASSAI ET AL., 2020), and very little attention has been given to the leaves of non-nitrogen-fixing species. There is therefore a need to evaluate other species in order to diversify the options available and reduce the dependence of farmers on a few species. The objective of the present work is therefore to evaluate the effect of leaf powders of *Tithonia diversifolia*, *Terminalia glaucescens*, *Annona senegalensis* and the combined effect of their leaves on the germination and growth of maize which is widely grown in the Sudano-guinea zone of Cameroon. Indeed, native to Central America, maize of the poaceae family, was the staple food of Amerindians before the discovery of America by Christopher Columbus (CARRARETTO, 2005). Its cultivation was introduced in Africa, particularly in Egypt around 1540 by the Turks and Syrians, and in the Gulf of Guinea region by the Portuguese around 1550 (MICHAEL ET AL, 2008). Today's maize is the result of both natural mutations and selections by humans from a wild ancestor, which could be teosinte, a grass growing spontaneously in Central America, or one of their common ancestors. Today, grown all over the world, maize has become the world's leading cereal, ahead of rice and wheat (CARRARETTO, 2005).

## MATERIAL AND METHODS

### Study site

The present study was conducted in the experimental field, inside the University of Ngaoundere Campus, Adamawa region, situated between 7°26’16’’ of North latitude and 13°33’34’’ of East longitude and occupied practically the center of Cameroon. This geographical location gives it a humid Sudano-guinea climate type according to SUCHEL (1987), with a unimodal rainfall distribution. The rainfall varies from 1200 and 2000 mm, with mean annual of 1400 mm. The rainy season extends from March to September, registering maximum amounts in August. The dry season is covering the rest of the year (COLLINS, 1985). The mean annual temperature is 22°C and the relative humidity is 70%. For HENGUE (1994), although this part of Cameroon is influenced by seasonal aridity due to the Harmattan, its climatic characteristics are reminiscent of those of a Sudano-guinea climate, while its rainfall is recall of those of subequatorial regions. The ferralitic soils are the dominant type (HUMBEL, 1971) derived directly from granite and gneisses, with low organic matter (less than 1%), low soil exchange capacity from 15 to 20 meq/100g and the pH about 4.7 to 5.6. Hydromorphic soils are found in the marshy depressions. The vegetation is diversified and composed of meadows, grassy savannahs, shrub and tree savannahs. The characteristic vegetation of the plateau is a shrub or tree savannah with *Daniellia oliveri* (Fabaceae) and *Lophira lanceolata* (Ochnaceae) (LETOUZEY, 1968). However, this vegetation is degraded due to zooanthropic factors (MAPONGMETSEM et al., 2005). The population of Ngaoundere is cosmopolitian and composed of the Dii (or Dourou), Mboum, Gbaya, Tikar, Mambila, Kaka, Ba射bouté, Haoussa, Fulani and Pere (MINEF, 1994). The main crop is corn and cassava, with respective yield of 2-3 and 3 $t.ha^{-1}$. Other activities like poultry and bovine farming, hunting, fishing and crafts are practiced at artisan scale in the region. The most crucial of the region's problems include the steady fall in soil fertility, damages caused by the partridge and ruminants on seedling and by termites on crops.

**Plant species choice and chemical characteristics of soils**

Mature green leaves (Figure 1a1, b1 and c1) of multipurpose species from the Sudano-guinea savannas of Adamawa were selected on the basis of their socio-economic importance and their phenology. These are *Tithonia diversifolia* (Hemsl.) A. Gray (Asteraceae), *Terminalia glaucescens* Planch. ex Benth (Combretaceae) and *Annona senegalensis* Pers. (Annonaceae). These species are highly valued by local populations because of their food importance and their interests in traditional medicine. The leaves of these plant species were harvested directly from the tree during their period of maturity (June to July 2021) in the savannahs of Ngaoundere, more precisely on the University Campus, sorted in order to eliminate the leaves already deteriorated, then dried (Figure 1a2, b2 and c2) in an oven for 3 days at a temperature of 60°C until constant dry mass. The dry leaves were then ground with a 2 mm filter Micro Hammer Mill culotti grinder and the powders (Figure 1a3, b3 and c3) were used for laboratory and field experiments.

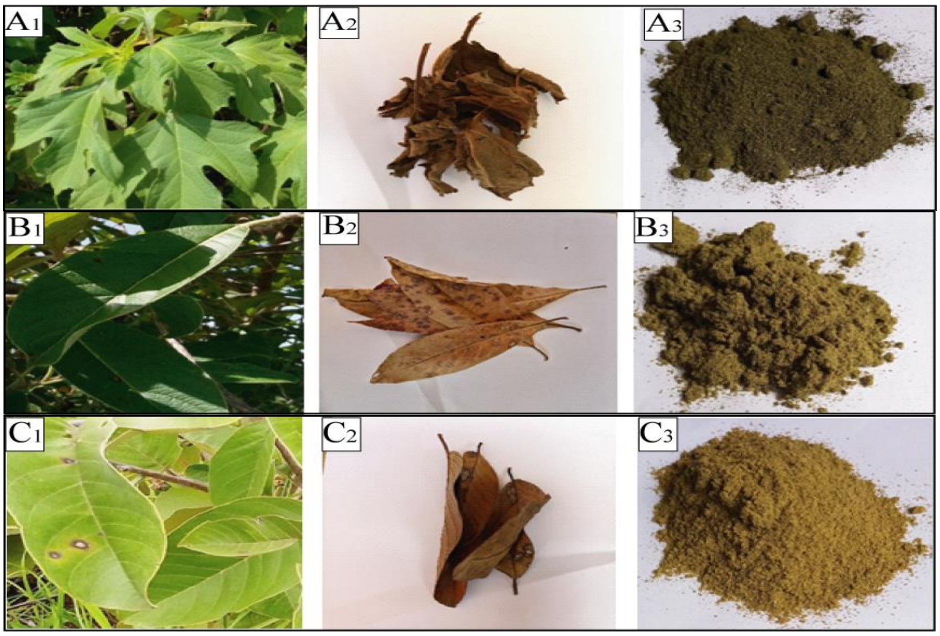


*Figure 1 : Fresh (1) and dried (2) leaves, and leaf powders (3) of Tithonia diversifolia (A), Terminalia glaucescens (B) and Annona senegalensis (C).*

Crop used is maize (*Zea mays* L.). Its seeds used are the SHABA variety certified by the Institute of Agronomic Research for Development (IRAD) of Cameroon. They are healthy, unbroken and wrinkle-free, with a germination rate of over 90%. Its reproduction cycle varies between 95 and 100 days from sowing to harvest.

**Methodology**

To assess the effects of leaf powders on the germination of maize (Zea mays), trials were carried out for 12 days in the laboratory in pots 15 cm long, 11 cm wide and 4 cm high, containing soil from the experimental site. After cleaning its surface, the superficial part of the soil, rich in organic matter, was taken and brought back to the laboratory, then sieved to 2 mm to homogenize their granulometry and cleared of debris of all kinds (roots, branches, leaves, etc.). The leaf powders were incorporated into the soil contained in the pots, the same day as the sowing at 3 doses (10, 20 and 30 g) and 25 seeds per pot. The experimental design is a split-plot with three repetitions. The main treatment is the type of powder (single and mixture powders) and the secondary treatment is the dose. The total number of pots was 66 (7 types of powder x 3 doses x 3 replicates + 3 controls). The different treatments are as follows:

**T0:** control
**T1 = TD:** 100 % of powder of *T. diversifolia ;*
**T2 = TG:** 100 % of powder of *T. glaucescens ;*
**T3 = AS:** 100 % of powder of *A. senegalensis ;*
**T4 = TD+TG:** 50 % de poudre de *T. diversifolia* and 50 % of powder of *T. glaucescens ;*
**T5 = TD+AS:** 50 % of powder of *T. diversifolia* and 50 % of powder of *A. senegalensis ;*
**T6 = TG+AS:** 50 % of powder of *T. glaucescens* and 50 % of powder of *A. senegalensis ;*
**T7 = TD+TG+AS:** 33,33 % of powder of each of three plant species.

The pots were kept in the laboratory and watered every two days with 50 ml of distilled water. The number of germinated grains was counted after 12 days and the germination rate (TG) was calculated according to the following formula:

TG (%) = (NGG)/NGS x 100

where NGG is the number of seeds germinated and NGS, the number of seeds sown.

To evaluate the effects of leaf powders on maize growth, an experiment was carried out in the field for 3 months. A experimental field of 22 m x 15 mm was marked out using a tape measure, cleared and plowed to a depth of about 20 cm, and separated into 24 plots of 2m x 4m, with 25cm separating alleys between the plots. Maize seeds were sown at the rate of four seeds per hill at spacings of approximately 30 cm x 25 cm, i.e. 20 plants per plot. As soon as the seeds germinated, the seedlings were thinned out to leave only one per hill. Maintenance care consisted essentially of refilling the voids one week after sowing, weeding and hoeing after the seedlings had emerged.

The treatments consist of a control without any input, an input of only powder of *T. diversifolia* (TD), *T. glaucescens* (TG) and *A. senegalensis* (AS), a mixture of 50% of the powders of *T. diversifolia* and *T. glaucescens* (TD+TG), of *T. diversifolia* and *A. senegalensis*, (TD+AS), of *T. glaucescens* and *A. senegalensis* (TG+AS), and mixture of 33.33 % of each of the three plant species (TD+TG+AS), at a dose of 25 grams per pocket in the field. The experimental design is a completely randomized block with three repetitions.

Growth parameters were observed for a period of 70 days (from August 17 to October 16, 2020) with an interval of 14 days from sowing. After the growth period, three maize plants were harvested by treatment, weighed fresh, then dried in an oven at 65°C for 48 hours, then reweighed to determine the fresh and dry biomass of maize plants. The growth parameters taken into account are the number of leaves, the collar diameter and the height of the plants.

**Chemical analyzes of leaves and soils**

Soil samples taken from each plot at a depth of 0-10 cm, before cultivation and at the end of the experiment (3 months) and those of the leaves of the three plant species were analyzed to determine the concentrations organic carbon, total nitrogen and phosphorus. These analyzes were carried out in the laboratory of the School of Geology and Mining (EGEM) of Meiganga, according to the methods described by AFNOR (1982), DEVANI et al. (1989) and RODIER (1978) respectively for carbon, nitrogen and phosphorus.

**Statistical analyzes of data**

Analysis of variance (ANOVA) followed by separation of means by the least significant difference (LSD) test at 5% were used to determine differences between treatments. The Pearson correlation coefficient (r) to relate the variables considered was used. The changes in the soil characteristics between the start and the end of the study were calculated using the formula: X%= 100*(X2-X1)/X1,

where X1 is the value of the parameter considered in beginning of the test and X2, the value of the parameter considered at the end. These analyzes were performed using STATGRAPHICS Plus 5.0 software.

## RESULTS AND DISCUSSIONS

**Chemical composition of leaves and soil**

Chemical element contents in leaves and soil of the study site vary significantly ($P<0.01$) between plant species (Table 1) and range from 38.67 to 44.42%, from 3.36 to 4.86% and from 0.50 to 0.32% respectively for carbon, nitrogen and phosphorus. The leaves of *T. diversifolia* have the highest concentrations of carbon (44.42%) and nitrogen (4.60%) and those of *A. senegalensis* are the richest in phosphorus (0.50%) and the lowest in carbon (38.67%). On the other hand, *T. glaucescens* has the lowest nitrogen (3.36%) and phosphorus (0.32%) in their leaves. The three plant species contain in their leaves nitrogen contents slightly higher than most species (1.79-3.80%) used in agroforestry to improve soil fertility (KAHO et al., 2011) and their phosphorus contents are similar (0.32 -0.50%). The nitrogen concentration in the leaves of *T. diversifolia* in our study is higher than that reported by KAHO ET AL. (2011), and that of phosphorus is similar. The ability of an agroforestry species to improve soil productivity depends, in fact, on its biomass yield, the quality of this biomass and its rate of decomposition (PALM, 199; COBO et al., 2002). The results show that the leaves of *T. diversifolia* are rich in carbon and nitrogen and average in phosphorus. In addition, Tithonia is a ruderal species that grows spontaneously around huts and roads and produces abundant and easily decomposable biomass. Therefore, this plant species has enormous potential compared to conventional species commonly used in agroforestry to improve soil fertility and which require high costs for their establishment and management.

The soil of the study site is poor in carbon, nitrogen and phosphorus than the leaves and this is explained by the acidity of the soil of the study site whose parental rock is from granite and by the abundance of iron and aluminum ions resulting in the red color of this soil as reported by HASSANA (2020). The values obtained for the nitrogen and phosphorus contents are lower than those reported by FEZEU (2006) and HASSANA (2020) on the soils of the Sudano-guinea savannahs of Cameroon. This difference could be explained by the difference in the sampling sites.

*Table 1:*

*Concentrations of carbon, nitrogen and phosphorous of leaves and soil.*

| **Nutrients** | *T. diversifolia* | *T. glaucescen* | *A. senegalensis* | **Soil** | **F** |
|---|---|---|---|---|---|
| **C (%)** | 44.42 ± 1.71[a] | 40.34 ± 0.95[b] | 38.67 ± 0.38[c] | 1.44 ± 0.02[d] | **2416.40*****|
| **N (%)** | 4.86 ± 0.61[a] | 3.36 ± 0.30[c] | 4.07 ± 0.30 [b] | 1.36 ± 0.16[d] | **97.58**** |
| **P (%)** | 0.40 ± 0.0003[b] | 0.32 ± 0.004[c] | 0.50 ± 0.004[a] | 0.01 ± 0.004[d] | **5346.67***** |

Values affected by different letters are significantly different. ** P < 0.01 and *** P< 0.001.

## Initial chemical composition of the soil and at the end

Table 2 presents the carbon, nitrogen and phosphorus contents of the soils before and after cultivation. The contents of different elements vary significantly among the treatments, from 1.57% for the initial value to 2.40% for the treatments amended with the powders of the leaves of *T. glaucescens* + *A. senegalensis* for carbon, from 1.45 % in the control at 2.14% for the *T. glaucescens* + *A. senegalensis* treatment for nitrogen and 0.02% for the control at 0.09% for the *T. glaucescens* + *A. senegalensis* treatment. The initial values are lower than those at the end of cultivation for all the treatments. The chemical element concentrations of the control are lower than those of all the other treatments, except for nitrogen where the control and the soil amended with TG powder do not differ significantly. The best amendments for carbon, nitrogen and phosphorus is the *T. glaucescens* + *A. senegalensis* treatment. The leaf powders of these three species improve the soil in organic matter and nutrients. Our results are in agreement with those of KAHO et al. (2004, 2011), who showed that an improvement in the nitrogen and phosphorus content of the soil after amendment with *Desmodium distortum* and *T. diversifolia*. Similar results were also obtained by HASSANA (2020).

*Table 2:*

*Chemical constituents of soil at the end of experiment (3 months) for different traitments*

| **Treatments** | **C (%)** | **N (%)** | **P (%)** |
|---|---|---|---|
| **Initial** | 1.44 ± 0.02 | 1.36 ± 0.16 | 0.01 ± 0.004 |
| **End of experiment** | | | |
| **Control** | 1.57±0.01[b] | 1.45±0.005[b] | 0,02±0.005[d] |
| **AS** | 2.34±0.01[a] | 2.07±0.01[a] | 0.07±0.005[b] |
| **TD** | 2.38±0.02[a] | 2.09±0.005[a] | 0.08±0.005[a] |
| **TG** | 2.31±0.01[a] | 1.55±0.05[b] | 0.04±0.005[c] |
| **AS + TD** | 2.35±0.005[a] | 2.01±0.01[a] | 0.05±0.05[c] |
| **AS + TG** | 2.40±0.01[a] | 2.14±0.03[a] | 0.09±0.05[a] |
| **TD + TG** | 2.35±0.01[a] | 2.02±0.01[a] | 0.05±0.05[c] |
| **TD + TG + AS** | 2.37±0.02[a] | 2.11±0.01[a] | 0.08±0.05[a] |
| **F** | 964.22*** | 857.32*** | 44.84*** |

*T. diversifolia* (TD), *Terminalia glaucescens* (TG) and *Annona senegalensis* (AS). Values affected by different letters in colon indicate values are significantly. *** p < 0,001.

**Effect of different treatments on soil chemical properties**

Soil chemical properties were analyzed at the beginning and end of the study to determine the effect of different treatments on the soil. Table 2 presents the results of these analyzes and the rates of change of each element that occurred in this soil during the study are presented in Table 3. After cultivation, although sometimes statistically significant differences do not appear between treatments, especially for carbon (Table 2), considerable variation rates were observed for the different chemical elements analyzed after cultivation (Table 3). Compared to the initial values shown in Table 2, the general trend (Table 3) shows an increase for the 3 chemical elements. This increase is the lowest for the control, with rates of 9.03% for carbon, 6.62% for nitrogen and 100% for phosphorus. The best amendment is the one with AS+TG powders for carbon (66.67%), nitrogen (57.35%) and phosphorus (800%). Similar results reported by KAHO et al. (2011) on the leaves of *T. diversifolia*.

*Table 3:*
*Increase in percentage of soil chemical elements after cultivation compagn for different treatments*

| Treatments | C (%) | N (%) | P (%) |
|---|---|---|---|
| **Control** | 9.03 | 6.62 | 100.00 |
| **AS** | 62.50 | 52.21 | 600.00 |
| **TD** | 65.28 | 53.68 | 700.00 |
| **TG** | 60.42 | 13.97 | 300.00 |
| **AS + TD** | 63.19 | 47.79 | 400.00 |
| **AS + TG** | 66.67 | 57.35 | 800.00 |
| **TD + TG** | 63.19 | 48.53 | 400.00 |
| **TD + TG + AS** | 64.58 | 55.15 | 700.00 |

*T. diversifolia* (TD), *Terminalia glaucescens* (TG) and *Annona senegalensis* (AS). Values affected by different letters in colon indicate values are significantly. *** p < 0,001.

**Effects of leaf powders on maize seed germination**

The effects of leaf powders and their doses on seed germination were tested on maize and the germination rate varied according to the treatments 12 days after sowing (Figure 2). The germination rate of the control (80%) is lower than those of all the treatments. The germination rate of maize seeds exceeded 90% for all treatments and at all doses, except the control and the amendments with mixtures of *T. diversifolia* + *A. senegalensis* and *T. glaucescens* + *A. senegalensis* leaf powders, where the germination rate reached 88 and 89% respectively.

Regardless of the dose of leaf powders applied, the leaves used show no toxicity with respect to the germination of maize, since their germination index exceeds 50%. According to ZUCCOONI ET AL. (1981), an organic fertilizer is considered non-toxic when the germination index exceeds 50%. Our results are in agreement with those of TOUNDOU (2016), who reported that the non-toxicity of composts with respect to maize regardless of the dose applied. KOLEDZI (2011) showed that the stimulating and inhibiting effect of the seed germination and plant growth subjected to certain organic fertilizers.

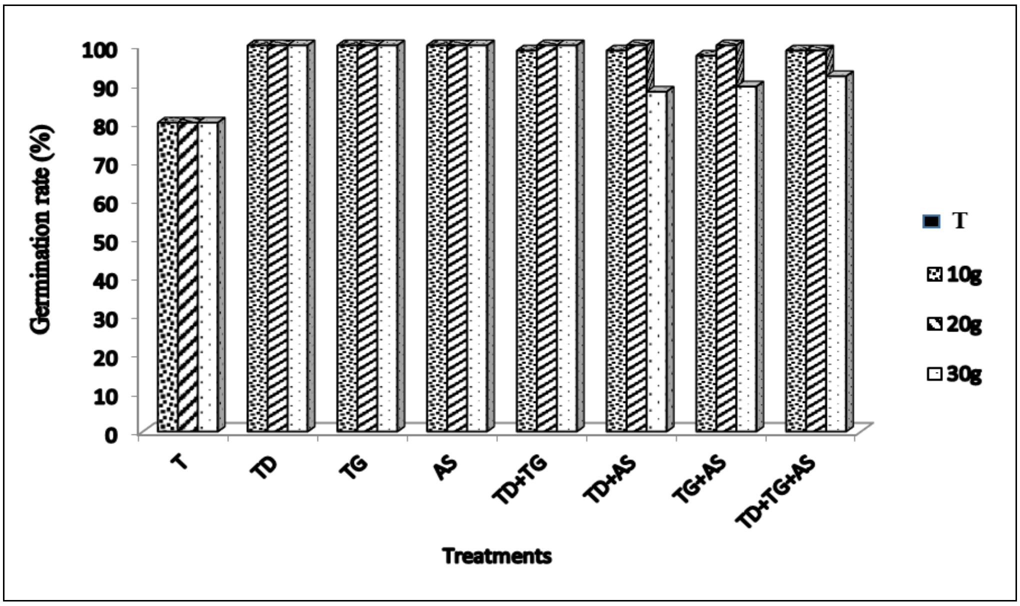


*Figure 2: Maize germination rate to different treatments 12 days after sowing.*
Control (T), *T. diversifolia,* (TD), *T. glaucescens* (TG) and *A. senegalensis* (AS).

**Effect of treatments on maize growth parameters**

The results relating to the influence of leaf powders and their mixtures on the growth parameters of maize plants such as height, number of leaves and neck diameter are illustrated in Figure 3. For all treatments, the growth parameters increase with the duration of culture. This growth is slow at the beginning of the amendments, then becomes rapid at the end of cultivation, in particular for the plant height which increases rapidly from 60 days after sowing (Figure 3a). Unlike plant height, leaf number and neck diameter increase linearly with cultivation time (Figure 3b and c). The evolution of the 3 growth parameters is significantly ($P<0.05$) different between the treatments, but the plants having received the amendments all have growth parameter values (height, number of leaves and neck diameter) significantly higher than those of the witness. The best amendment for the three growth parameters is that of mixtures of powder of *T glaucescens* associated with that of *A. senegalensis*. The other treatments show changes in the three growth parameters intermediate. Similar results have been reported in the litter literature. Indeed, DIALLO (2005) showed that the number of leaves produced by maize varies with the type of litter in Senegal and the amendments made improved the evolution of the number of leaves. Similarly, MASSAI ET AL. (2020) reported that the evolution of the neck diameter of maize plants is improved by the addition of amendments with litters of *A. senegalensis, Parkia biglobosa* and *Terminalia macroptera*.

At 70 days after sowing, the growth parameters of maize plants vary significantly ($P<0.001$) between treatments (Table 4). The values of these 3 parameters for all the treatments are significantly higher than those of the control. The best amendment for the three parameters remains the mixture of powdered leaves of *T. glaucescens* and *A. senegalensis*.

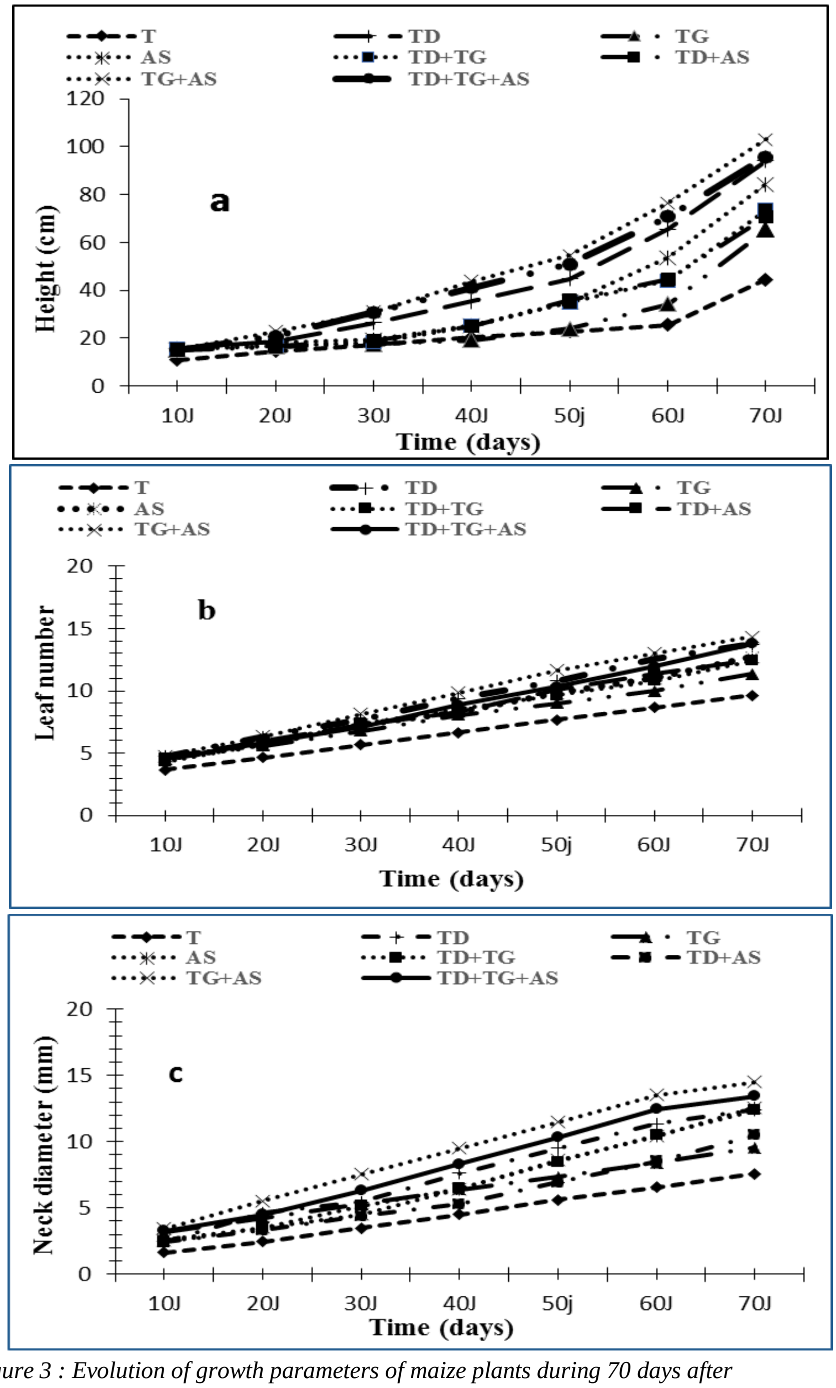


*Figure 3 : Evolution of growth parameters of maize plants during 70 days after sowing, plant height (a), leaf number (b) and neck diameter (c).*

Control (T), *T. diversifolia* (TD), *T. glaucescens* (TG), *A. senegalensis* (AS), *T. diversifolia* + *T. glaucescens* (TD+TG), *T. diversifolia* + *A. senegalensis* (TD+AS), *T. glaucescens* + *A. senegalensis* (TG+AS) and *T. diversifolia* + *T. glaucescens* + *A. senegalensis* (TD+TG+AS).

*Table 4:*
*Variations of growth parameters of maize plants at 70 days afer sowing for different treatments*

| **Teatments** | **Height (cm)** | **Leaf number** | **Neck diameter (cm)** |
|---|---|---|---|
| **T** | 29.44 ± 1.78g | 9.66 ± 0.48e | 7.56 ± 0.22f |
| | 94.21 ± 2.12b | 13.73 ± 0.45b | 12.42 ± 0.07c |
| **TG** | 65.20 ± 3.38f | 11.33 ± 0.48d | 9.54 ± 0.20e |
| **AS** | 84.24 ± 2.35c | 12.73 ± 0.45c | 12.56 ± 0.96c |
| **TD + TG** | 73.60 ± 2.90d | 12.4 ± 0.50c | 12.38 ± 0.23d |
| **TD + AS** | 70.88 ± 0.71e | 11.46 ± 0.51d | 10.47 ± 0.32d |
| **TG + AS** | 103.07 ± 1.71a | 14.33 ± 0.48a | 14.49 ± 0.24a |
| **TD + TG + AS** | 95.62 ± 2.55b | 12.8 ± 0.41b | 13.43 ± 1 ;52b |
| **F** | 1100.71*** | 159.92*** | 171.08*** |

Control (T), *T. diversifolia* (TD), *T. glaucescens* (TG), *A. senegalensis* (AS), *T. diversifolia* + *T. glaucescens* (TD+TG), *T. diversifolia* + *A. senegalensis* (TD+AS), *T. glaucescens* + *A. senegalensis* (TG+AS) and *T. diversifolia* + *T. glaucescens* + *A. senegalensis* (TD+TG+AS).
Values affected by different letters are significantly different. *** P <0,001.

In general, the powders of the leaves of the three plant species (*T. diversifolia, T. glaucescens* and *A. senegalensis*) and their mixture provided a significant improvement in the growth parameters of maize. This can be justified by the gradual release to the soil of the chemical elements present in the leaves, particularly nitrogen and phosphorus. The general trend of improved germination, height, diameter, number of leaves and biomass by litter has been reported in the literature on various crops (DIALLO ET AL., 2008; FODEUBA, 2009, MUYAYABANTU EL AL., 2012; TSHIMANGA, 2014; MASSAI ET AL., 2020). Indeed, FODEUBA (2009) reported that litter powder increases the growth parameters of corn and tomato compared to the control. The explanations put forward in the literature are the availability of nutrients contained in the different litters, more particularly nitrogen or lignin (DIALLO ET AL., 2008). According to DIALLO (2005), the decomposition of lignin gives soluble sugars which are used for nutritional and energy purposes by plants, which leads to greater crop growth. Similarly MUKENDI AND NGOIE (2015) also showed that the gradual release of mineral elements from the biomass of plant species would have stimulated up to 60 days of vegetation, the growth parameters of maize. On the other hand, XUAN et al. (2004) reported that extracts from *A. indica* litter at different doses (0.25; 0.5 and 1 t/ha) significantly inhibited the height and biomass of several plants.

**Effect of treatments on Biomass**

The biomass of maize plants obtained after amendments with single leaf powders and their mixtures at 70 days after sowing varies significantly (P<0.001) between treatments, from 23.53g for the control to 98.57g for the treatment of *T. glaucescens* + *A. senegalensis* (Figure 5). The other treatments show intermediate values. This result shows that leaves and litter can play a decisive role in soil fertility by their quantity and quality. Similar results were reported by Massai et al. (2020) on maize and tomato. In fact, they found that soil amendment with *A. senegalensis* and *Terminalia macroptera* litters significantly improved the biomass of tomato and maize plants compared to the control, whereas amendment with *Parkia biglobosa* litter did not improve maize biomass. They attributed these differences to the chemical quality of the litters.

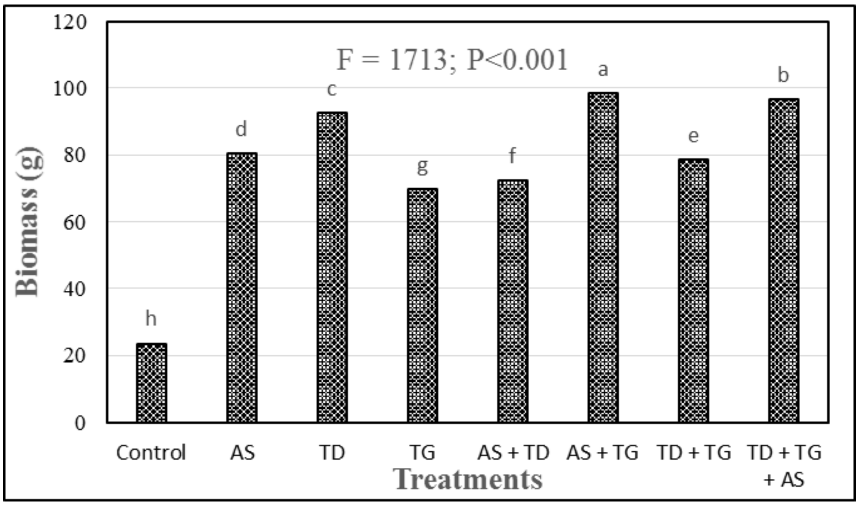


Figure 5: Biomass (g) of maize in different treatments
Control (T), *T. diversifolia*, (TD), *T. glaucescens* (TG), *A. senegalensis* (AS), *T. diversifolia* + *T. glaucescens* (TD + TG), *T. diversifolia* + A. senegalensis (TD + AS), *T. glaucescens* + A. senegalensis (TG + AS) and *T. diversifolia* + *T. glaucescens* + *A. senegalensis* (TD + TG + AS)

## CONCLUSIONS

This study aims to evaluate the effect of leaf powders of *Tithonia diversifolia, Terminalia glaucescens* and *Annona senegalensis* on the seed germination and growth of maize. The powders of these three species and their mixtures did not show toxic effects on the seed germination of maize at the three doses (10 g, 20 g and 30 g) and 20 g is the best dose for seed germination. Growth parameters such as height, number of leaves and neck diameter as well as the biomass of maize plants varied significantly between treatments. All the amendments significantly improved the growth parameters and the biomass of the maize plants compared to the control. The best amendment is the mixture of *T. glaucescens + A. senegalensis,* which better improves all growth parameters and biomass, with values of 106.9 cm for height, 14 for number of leaves, 14.9 mm for the neck diameter and 98.57 g for the biomass. The leaves of these three plant species are richer in C, N and P than the soil of the study site before cultivation. At the end of cultivation, all the treatments improved the C, N and P contents of the soil. The best amendment is the mixture of *T. glaucescens + A. senegalensis* which resulted in an increase of 66.67% for carbon, 57.35% for nitrogen and 800% for phosphorus. The use of leaf powders of these plant species and their mixtures contribute to improving the quality of the soils of the Sudano-guinea savannahs of Ngaoundere Cameroon in general and that of Dang in particular. These species are good candidates for domestication

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