Agricultural Science Research Journal
ISSN 2026-6073
ZANGO *et al*, Volume (11) Issue (1): 14 – 24 January – 2021.
RESEARCH PAPER

Effect of *Moringa oleifera* lam leaf extracts on growth and productivity of maize (*Zea mays* L.)

Fadilatou ZANGO[1], *Abel KADÉBA[1,2], Oumarou SAMBARE[1,3] and Joseph Issaka BOUSSIM[1]

[1]Laboratoire de Biologie et Ecologie Végétales, Université de Ouagadougou, 03 BP 7021, Ouagadougou 03, Burkina Faso.

[2]Université de Dédougou, Institut des Sciences de l'Environnement et du Développement Rural, BP 176 Dédougou, Burkina Faso

[3]Institut des Sciences, 01 BP 1757 Ouagadougou 01, Burkina Faso

*Corresponding author email: kadebab@yahoo.fr

*Corresponding Author

* Abel KADÉBA[1,2]

[1]Laboratoire de Biologie et Ecologie Végétales, Université de Ouagadougou, 03 BP 7021, Ouagadougou 03, Burkina Faso.

2Université de Dédougou, Institut des Sciences de l'Environnement et du Développement Rural, BP 176 Dédougou, Burkina Faso

*Corresponding Author Email: kadebab@yahoo.fr

Abstract

Cultivation of maize (*Zea mays* L.) is one of the most important value chains for food security in countries of West and Central Africa. The maize industry is undergoing a revolution due to increased demand from the poultry sector, beverages and other processed products. The implementation of strategies to increase its output (growth and productivity) is necessary to further boost this sector. The objective of the present study is to examine the effect of aqueous extracts of *Moringa oleifera* Lam leaves on the growth and productivity of three varieties of maize (Barka, SR21 and FBC6) from Burkina Faso. An experimental device, of the split-plot type with three repetitions and nine treatments has been installed within the CNSF. For each variety of maize three doses of extracts of *moringa oleifera* were applied (0%, 25% and 50%). Minitab software was used to compare the different means through ANOVA and Turkey test. The results of the various tests showed that the application of the aqueous extract of Moringa leaves at the tested doses promoted the growth and increased yield of maize in the field. The longest spike length was 17.33 cm observed at the 50% aqueous extract dose. Also, the highest spice diameter is observed at the 50% (44.21cm) and 25% (42.80 cm) dose. The variety FBC6 has a longer spike length than Barka and SR21. The spice diameters of the three varieties are similar. The number of seeds per spice is higher for the FBC6 variety compared to Barka and SR21. Significant differences were observed for growth parameters and yield components (plant diameter, spice length, spice diameter, number of seeds per spice). Furthermore, there was no significant difference in sizes between the varieties. The application of the aqueous extract of the leaves of *Moringa oleifera* at a dose of 25% and 50% contributes to the improvement of the productivity of the three varieties of maize, the study recommends the application of extract of *Moringa oleifera* to the 50% dose. We suggest that further research be undertaken in a farmer's field to confirm the results obtained.

Keywords: *Zea mays*, *Moringa oleifera*, Bio-stimulant, Yield

Introduction

Cereal crops occupy an important place in the world in the fight against food insecurity. Cereals are widely used in animal and human food and for industrial uses. In Burkina Faso, the area sown to cereals is estimated at 3,646,007 ha, or 67.3%, distributed mainly between white sorghum, millet and maize (DGESS, 2015). Maize (*Zea mays* L.), from the grass family (Poaceae), is the first cereal cultivated in terms of quantity and area, ahead of wheat and rice. It is cultivated in a variety of conditions ranging from tropical to temperate climates. Maize occupies the 3rd place among cereal crops with a total production of 1.53 million tonnes.

The implementation of modern and simple techniques based on plant extracts could improve the agro-morphological parameters (growth and yield) of maize and therefore the satisfaction of the daily needs of the populations. *Moringa oleifera* Lam. is a species that belongs to the Moringaceae family. The genus Moringa includes around ten species native to Asia, Africa and Madagascar. Its introduction to East Africa took place at the beginning of the 20th century through trade and maritime trade during this period (Foidl et al. 2001). It is a medium-sized tree species that has grown in importance due to its multiple uses and adaptability to dry and hot climates

Several studies carried out in different countries have proven the different virtues of this plant, both nutritional and therapeutic, thanks to the richness of its different organs and in particular the leaves in nutritional elements (Fahey, 2005). *Moringa oleifera* leaves therefore contain seven times more vitamin C than orange, four times more calcium and twice as much protein than milk, three times more potassium than bananas, three times more iron than spinach Indians and four times more vitamins than carrots (Hussain et al. 2012). It contains protein, fiber, sulfur, calcium, iron, ascorbic acid, thiamine choline, phosphorus riboflavin, potassium, nicotinic acid and a complete profile of amino acids in sufficient quantity (Bau et al. 1994). In herbal medicine, the leaves are crushed and the powder put into capsules or sachets. This species with various virtues could therefore be used to test the productivity of maize. Indeed, studies have shown that the 80% ethanol extract obtained from Moringa leaves contains growth factors called cytokinin hormones (Makkar and Becker, 1996).

This extract can be used as a spray on the leaves to speed up the growth of young plants. This treatment with growth hormones also increases the robustness of the plants and their resistance to disease. Spraying the leaves with Moringa extract prepared with 80% ethanol and then diluted in water produces significant effects: more vigorous growth over a longer life cycle; stronger roots, stems and leaves, larger fruits, higher sugar content, etc. (Foidl, 2001).

With a view to contributing to the fight against food insecurity by setting up simple techniques to improve the growth and productivity of maize, we are testing *Moringa oleifera* extracts through the theme "Effect of extracts from Moringa oleifera lam leaves on the growth and productivity of maize (Zea mays L.)".

The general objective of this study is to examine the effect of extracts from *Moringa oleifera* Lam leaves as a bio-stimulant on the growth and productivity of maize (*Zea mays* L.).

Specifically, it involves (1) evaluating the growth and productivity of three varieties of maize without any treatment, (2) evaluating the effectiveness of extracts from *Moringa oleifera* Lam leaves at different doses on the growth and productivity of three maize varieties.

To achieve these objectives, the following hypotheses were tested:

1) Without treatments with *Moringa oleifera* extracts, the three varieties of maize grow differently with low yields;
2) *Moringa oleifera* extracts applied to the three varieties increase their yields depending on the dose.

Materials and methods

The study site

The study was carried out in the experimental nursery of the Center National de Semences Forestières (CNSF). The CNSF, a public scientific, cultural and technical establishment (EPSCT) is placed under the supervision of the Ministry of the Environment, Green Economy and Climate Change (MEEVCC). Its head office is located north of the city of Ouagadougou (kossodo district) on national road number 3 (RN 3) Ouaga-Kaya axis, at the edge of Bangr-wéogo Park (figure 1).

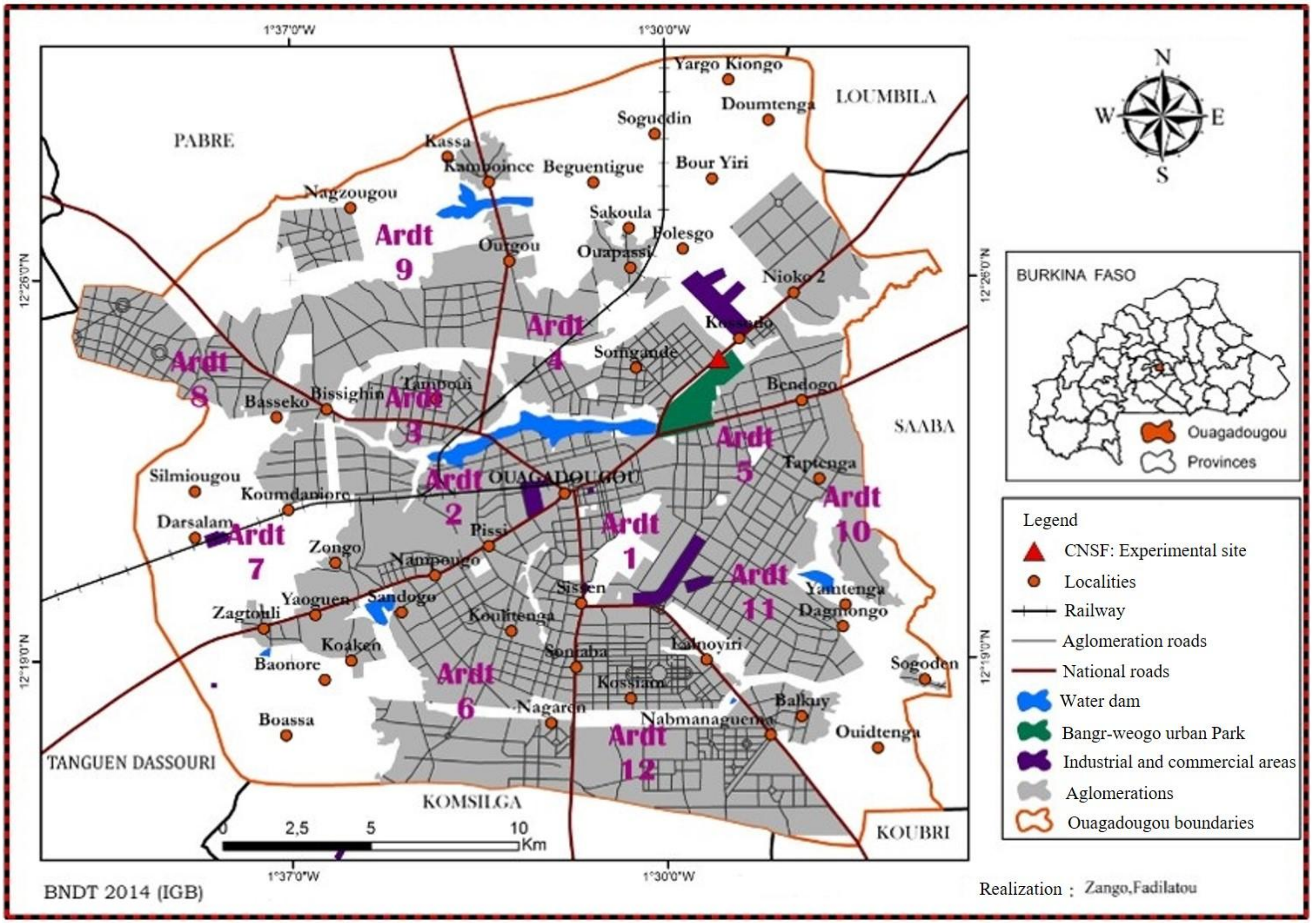

Figure 1: Location of the experimental site

Plant material

The plant material consists of basic seeds of three varieties of Zea mays developed by INERA and leaves of Moringa oleifera L.

The three varieties of *Zea mays* are:

- Variety 1: Farako Ba Composite n ° 6 (FBC 6) results from a mixing of eight composites (SANOU, 1993). It's a spicely variety. She has a 91 day cycle. The plant is 215 cm high. It has good resistance to lodging and to breakage. It has moderate resistance to rust and is tolerant to several viruses. Yellow to orange in color, it has a dentate horny texture and a yield of 5.6t / ha (SANOU, 1993)
- Variety 2: SR21 is a composite variety. The plant is 180 cm high with good resistance to lodging and breakage. She has a 95 day cycle. It is rust tolerant and resistant to viruses. White in color, it has a semi-horny texture and a yield of 5.1t / ha (SANOU, 1993).
- Variety 3: Barka maize is an extra early composite variety resulting from the mixing of six lines resistant to drought (SANOU, 2007). This variety has a height of 175 cm and good resistance to lodging and breakage. She has an 80 day cycle. It has white seeds with a wedge-shaped horny texture and a yield of 5.5 t / ha (SANOU, 2007).

For *Moringa oleifera* L. it is the leaf extract used as a bio-fertilizer in three doses D0: no concentration. D1: 25% concentration of extract and D2: 50% concentration.

Table 1: The different treatments and their characteristics

Treatments	Characteristics
FBC6	FBC6 without moringa leaf extract
FBC6	FBC6 with 25% moringa leaf extract
FBC6	FBC6 with 50% extract of moringa leaves
SR21	SR21 without moringa leaf extract
SR21	SR21 with 25% moringa leaf extract
SR21	SR21 with 50% moringa leaf extract
Barka	Barka without moringa leaf extract
Barka	Barka with 25% moringa leaf extract
Barka	Barka with 50% moringa leaf extract

The experimental device

The experimental set-up used is of the nine-treatment split-plot type with three repetitions per treatment. Each repetition has 2 elementary plots, made up of six rows. The main plots include the varieties of maize and the secondary plots the doses of moringa extracts. The spacing was 40cm, 50cm, and 30cm respectively between repeats, plots, and rows. The seedlings were made at the rate of two seeds per pocket with a spacing of 20 cm between the pockets. The total area of the test was 86.4 m^2.

The reference controls in the study did not benefit from treatment with aqueous extracts of moringa leaves. The treatments were done twice a month. The first spraying took place on the 14^{th} day after sowing, ie July 28^{th}. Thereafter, the sprays were made during the critical phases. Spraying was done using a backpack sprayer. Observations were made on three central lines of each plot.

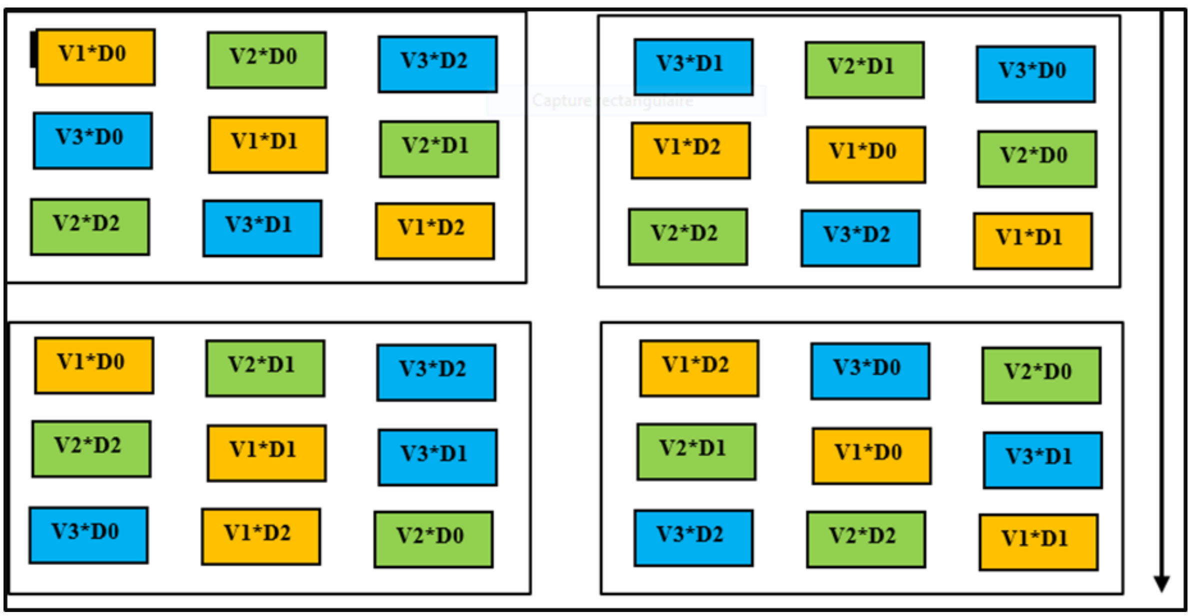

Figure 2: Experimental setup

V1 = FBC6 variety, V2 = SR21 variety, V3 = Barka variety, D0 = dose without Moringa extract (control), D1 = 25% dose, D2 = 50% dose

Planting of maize

The trial was set up on July 12, 2019 after manual weeding. Maize was sown in rows due to two seeds per pocket and seeded to one plant per pocket on the 14th day after sowing.

Collection and preparation of aqueous extracts

The preparation of the aqueous extracts was carried out in the CNSF laboratory according to the method of Basra (2016). In our case we beat the fresh leaves with a pestle in a mortar unlike Basra who wrapped the leaves in a cheese cloth and beat them with a wooden stick to crush them. The extracts were obtained by grinding, after weighing, fresh leaves of moringa. So to have 20 liters of moringa leaf extract, we weighed the leaves to obtain 500 grams (g) (D1) and 1000g (D2). Next, we crushed the fresh leaves (D1) and (D2) separately using a mortar and then we soaked D1 and D2 in two different containers each containing 20 liters of tap water. Finally, we filtered the mixtures to obtain with D1 the dose of 25% and D2 the dose of 50%. The resulting extracts from the fresh moringa leaves are collected in a 20 liter backpack sprayer and sprayed on the maize plants the same day a few hours after preparation.

Spraying the extract

Foliar sprays were made every two weeks from emergence to flowering using a backpack sprayer. The sprays with aqueous extract of fresh moringa leaves were made in the early morning because the bio-fertilizers must enter the plant to act. For this it must pass through the cuticle of the leaves. In normal times, the cuticle is very compressed, therefore waterproof. The only time the product can pass through it is when it is dilated (PERRIOT, 2020).

The cuticle allows plants to retain their moisture.

Collection of agro-morphological data

Data were collected from the 28th day after sowing at the CNSF after the first treatment with moringa extract. In total, 5 quantitative traits were collected during the development cycle of maize plants. These traits have been grouped into growth traits and variety performance traits.

Agro-morphological growth characteristics of varieties

These are the height of the plant, the diameter of the plant and the number of leaves per plant.
The height of the plant: it corresponds to the size of the plant from the base to the last node before the panicle (BANHORO, 2019). The height measurement was made on a sample of nine plants randomly selected from the center lines of each treatment. The measurement in centimeters was recorded from the base of the plant to the last leaves before the panicle using a graduated wood.
The diameter of the plant: the measurement was made at the base of the plant using a caliper.
The number of leaves per plant: this involved manually counting the number of leaves of the nine plants chosen, taking into account the leaves at the base (often fallen).

Agro-morphological characteristics of variety yield

There are three agro-morphological performance characteristics of the varieties observed. These are the length of the spice produced, the diameter of the spice and the number of seeds per spice.

The length of the spice: the measurement in centimeters was made using a double decimeter from the base to the top of the spice.
The diameter of the spice: the measurement was made at the level of the middle of the spice using a caliper.
The number of seeds per spice: the counting of the number of seeds per spice of each variety concerned 9 plants. The number of kernels on a single spice was systematically counted per plant.

Collection and preparation of the extract

To have 20l of moringa leaf extract, we proceed as follows:

- sampling of fresh moringa leaves;
- Weigh the leaves to obtain 500 gram (g) (D1) and 1000g (D2);
- grinding with a mortar the fresh leaves (D1) and (D2) of moringa separately
- Soak the leaves (D1) and (D2) grind in 20 liters of tap water respectively;
- Filter the mixtures obtained (D1) and (D2);
- Place in a 20 l backpack sprayer and spray.

Spraying extracts

Foliar sprays were made two weeks after emergence. Then, they were done every two weeks thereafter until flowering. A total of three sprays were carried out. The first moringa treatment was carried out on the 14th day after sowing. The second moringa treatment was made 35 days after sowing and the 3rd spraying 41 days after sowing. The extract of the moringa leaves is sprayed onto the leaves of the maize plants using a backpack sprayer. The sprays were made early in the morning due to the hot climate (BASRA, 2016). If the extract is not to be used within five hours, it should be stored in the freezer until use (Foild, 2001). In our case, the extract was used directly after preparation.

Assessment of growth and productivity parameters

The growth assessment concerned the maize plant and covered two parameters (total height and number of leaves). The productivity assessment concerned the maize cob and covered three parameters (length of the cob, diameter of the cob and number of seeds per cob).

Data collection and analysis

The data collected on the growth and yield parameters of the maize plants were subjected to analysis of variance (ANOVA) to compare the effect of the different treatments on the growth and yield of the maize. Turkey's test was used to compare the means of the parameters. Significant tests are marked at $p < 5\%$. Analyzes were performed using Minitab software version 18.1. All the data collected was entered on the EXCEL 2013 spreadsheet.

Results and discussion

Results

Growth parameters of maize varieties

Height growth of the plant

Depending on the variety

Analysis of variance, carried out on the height of the maize plants, revealed a highly significant difference (p<0.001 ***) between the varieties (Table 2). The comparison test of means by Turkey's method for this variable made it possible to distinguish two groups (table 3): the variety FBC6 and SR21 all of group A have the greatest plant heights (respectively 125.34 ± 57.50A and 123.97 ± 44.62 A) and the Barka variety of group B with a plant height lower than the first two (112.03 ± 28.23 B). There is no significant difference in terms of size between the FBC6 and SR21 varieties.

Table 2: Results of the analysis of variance of the growth parameters according to the variety and the dose

Variables	Source	DL	F-Value	P-Value
HP	Varieties	2	17,52	0,000
	Dose	2	21,81	0,000

Table 3: Growth in height (cm) of plants depending on the variety

Variables	Varieties	Medium
Height	FBC6	125,34 ±57,50A
	SR21	123,97±44,62 A
	Barka	112,03±28,23 B

Depending on the dose

Analysis of variance, carried out on the height of maize plants, revealed a significant difference (p<0.001 ***) between the different doses (Table 4). The two-by-two comparison of the means by Turkey's method at a confidence level of 95% made it possible to distinguish two groups: a first group A which shows that there is no significant difference in size for the doses 25 % and 50%. The plants have a larger size (respectively 126.20 ± 42.66 A and 124.21 ± 46.97 A). Group B with a dosage of 0% shows plants with sizes smaller than plants of group A (i.e. 110, 94 ± 49.45 B) (table 5)

Table 4: Growth in height (cm) of plants as a function of dose

Variables	Doses	Medium
HP	0%	110,94±49,45 B
	25%	126,20±42,66 A
	50%	124,21±46,97 A

Growth in diameter of plants

Depending on the variety

The ANOVA test carried out on the diameter of the plants at the level of the three varieties revealed a significant difference (p<0.05 *) (table 5) between the varieties. The comparison of the means by the Turkey test made it possible to distinguish three groups (table 6) including A, B, and AB. The variety FBC6 (16.21 ± 4.27AB 16.2149 cm) of group AB has a plant diameter intermediate between the plants of varieties SR21 (16.37 ± 3.82 A 16.3730cm) of group A and Barka (15.55 ± 3.59 B 15.5462cm) of group B. (table 6).

Table 5: Results of the analysis of variance of the growth parameters according to the variety and the dose

Variables	Source	DL	F-Value	P-Value
Diameter	Variety	2	3,86	0,021
	Dose	2	24,53	0,000

Table 6: Growth of the diameter (cm) of plants according to the variety

Variables	Varieties	Medium
Diameter	SR21	16,37±3,82 A
	FBC6	16,21± 4,27 A B
	Barka	15,55±3,59 B

Depending on the dose

The ANOVA test carried out on the diameter of the plants at the level of the three varieties revealed a significant difference (p<0.001 ***) between the doses used (Table 5). The comparison of the means by the method of Turkey at 95% made it possible to distinguish three groups: this is group A which corresponds to the dose of 25% with the largest diameters (17.03 ± 3.74 A), group B (50%) and group C with respective diameters of 16.29 ± 4.13 B and 14.82 ± 3.91 C (Table 7).

Table 7: Growth in diameter (cm) of plants as a function of dose

Variables	Doses	Medium
DP	0%	14,82±3,91 C
	25%	17 ,03±3,74 A
	50%	16,29±4,13 B

Number of leaf (NL)

Depending on the variety

Analysis of variance, for the variable number of leaves of maize plants, revealed a significant difference (p = 0.005) between varieties. The averages of the number of leaves compared give two distinct groups (Table 9). The first group (A) which corresponds to the FBC6 and SR21 varieties with leafy plants on average respectively 12.92 ± 2.64A and 12.89 ± 2.04A leaves. Then group B (Barka) with an average of 12.56 ± 1.82 B leaves (table 9).

Table 8: Results of the analysis of variance of the growth parameters according to the variety and the dose

Variables	Source	DL	F-Value	P-Value
NF/P	Variétés	2	5,34	0,005
	Dose	2	121,99	0,000

Table 9: Number of leaves per plant depending on the variety

Variables	Varieties	Medium
Number of leaf	FBC6	12,92 ±2,64A
	SR21	12,89±2,04 A
	Barka	12,56±1,82 B

Depending on the dose

Analysis of variance, for the variable number of leaves of maize plants, revealed a significant difference (p = 0.000) between the doses used (Table 10). The averages of the number of leaves compared give two distinct groups (Table 11). The 25% and 50% doses of the same group A are significantly the same with respective means of 13.43 ± 1.90A and 13.25 ± 1.32A leaves. They show plants with more leaves than plants in group B (0%) with an average of 11.69 ± 2.136 B leaves.

Table 10: Results of the analysis of variance of the parameter number of leaves per plant according to the variety and the dose

Variables	Source	DL	F-Value	P-Value
NF/P	Variétés	2	5,34	0,005
	Dose	2	121,99	0,000

Table 11: Number of leaves per plant depending on the dose

Variables	Doses	Medium
NF/P	0%	11,69±2,136 B
	25%	13,43± 1,90A
	50%	13,25±1,32 A

Maize Variety Yield Parameter

Spice length (SL)

Depending on the variety

Analysis of variance for the spice length variable revealed a highly significant difference (p = 0.000) between the treatments (Table 12). The comparison of the means for this variable made it possible to distinguish two groups (Table 13). Group A corresponds to the variety FBC6 with the greatest length of spice (16.68 ± 3.37 A 16.6815 cm), the group B (barka and SR21) with the smallest spice lengths (15.14 ± 2.83B 15.1394cm and 14.40 ± 2.84 B 14.3991 cm respectively).

Depending on the dose

Analysis of variance for the spice length variable showed that there is a highly significant difference (p = 0.000) between the doses (Table 12). The comparison of the means by Turkey's method at the 5% threshold shows that the plants at the 50% dose of group A give larger heads (17.33 ± 2.42A 17.3265 cm), the dose 0% of group C with smaller heads (12.71 ± 2.60 C 12.7083cm) and the dose 25% of group B with heads of size intermediate to the first two (16.19 ± 2.47B 16.1852 cm) (table 14).

Table 12: Result of the analysis of variance of the yield parameters according to the variety and the dose

Variables	Source	DL	F-Value	P-Value
LE	Treatment	2	25,83	0,000
	Dose	2	109,41	0,000

Table 13: Yield of maize plants according to treatment

Variable	Treatment	Medium
LE	FBC6	16,68±3,37 A
	Barka	15,14 ±2,83B
	SR21	14,40±2,84 B

Table 14: Maize plant yield as a function of dose

Variable	Dose	Medium
LE	0%	12,71±2,60 C
	25%	16,19 ±2,47B
	50%	17,33± 2,42A

Spice diameter (SD)

Depending on the dose

The results of the analysis of variance revealed that there was a highly significant difference (p = 0.000) between the doses. However, the comparison of the means by the Turkey method at the 5% threshold shows us three distinct groups of which a group A which corresponds to the 50% dose gives the largest diameters (44.21 ± 4.12A), a group B corresponding at the 25% dose at an average spice diameter (42.80 ± 4.06B) and group C at the 0% dose with smaller spice (37.77 ± 3.55C) (Table 17)

Depending on the variety

For the diameter of the spices parameter, the analysis of variance reveals that there is no significant difference between the varieties (p = 0.579) (Table 15). The comparison of the means shows that all the varieties have the same spice length (around 41 cm) (Table 17).

Table 15: Result of the analysis of variance of the spice diameter parameter as a function of the variety and the dose

Variables	Source	DL	F-Value	P-Value
Spice diameter	Variety	2	0,55	0,579
	Dose	2	75,28	0,000

Table 16: Yield of spice diameter as a function of dose

Variable	Dose	Medium
DE	0%	37,77 ±3,55C
	25%	42,80 ±4,06B
	50%	44,21± 4,12A

Table 17: Yield of spice diameter according to variety

Variable	Variety	Medium
DE	Barka	41,92± 4,25A
	FBC6	41,43±4,22 A
	SR21	41,43± 5,71A

Number of seeds per spice (NSS)

Depending on the dose

The results of the analysis of variance revealed that there is a highly significant difference (p = 0.000) between the doses. However, the comparison of the means by the Turkey method at the 5% threshold shows us that the number of seeds is higher with the 50% dose (486.945 ± 83.04 A). It is approximately double the number of seeds in the 25% dose (282.64 ± 76.88 C) (Table 20).

Depending on the variety

For the parameter number of seeds per spice, the analysis of variance also reveals a very highly significant difference (p = 0.000) (table 18) between the varieties. Comparison of the means allowed us to distinguish three distinct groups (Table 7). The first group which includes the FBC6 varieties has a higher number of seeds per spice with an average of 423,827 seeds. The second compound of the Barka variety with an average number of seeds per spice of 401.16 seeds. Finally the SR21 with 380.65 seeds on average (table 20).

Table 18: Result of the analysis of variance of the parameter number of seeds per spice as a function of the variety and the dose

Variables	Source	DL	F-Value	P-Value
Number of seeds / spice	Variety	2	8,22	0,000
	Dose	2	198,14	0,000

Table 19: Yield of the number of seeds per spice according to the dose

Variable	Dose	Medium
NGE	0%	282,64±76,88 C
	25%	436,06±73,06B
	50%	486,945±83,04 A

Table 20: Yield of the number of seeds per spice according to the variety

Variable	Variety	Medium
NGE	FBC6	423,83±124,50A
	Barka	401,16±101,57 AB
	SR21	380,65±117,80B

Discussion

Our results showed that the aqueous extract of Moringa leaves had a positive effect on the growth and development of maize plants in the field. Treatments of plants with Moringa extracts at doses of 25% and 50% had a positive impact on the height of the plants of the three varieties of maize (FBC6, SR21 and Barka). Thus, all of the treated plants had feet taller than the control. Abdel (2016) reported that moringa extract significantly increased height, number of leaves per plant, neck diameter, and yield parameters of garlic (Allium sativum.). This fertilizing action of plant growth by the aqueous extract of moringa leaves has been proven by several authors (Abdel, 2016; Awady, 2003). In addition, Culver et al. (2012) showed that moringa leaf extract combined with 80% alcohol increased the height of tomato plants when applied once every two weeks until maturity from two weeks after germination. According to (Saheed *et* *al*., 2001), plant height is an important growth trait directly related to the productive potential of plants in terms of forage and grain yield. Also, the acceleration of plant growth is explained by the presence of a very high concentration of zeatin in moringa leaves and the presence of other excellent growth stimulators such as phenolics, acrobats, potassium, calcium and iron which are excellent growth stimulators (Awady, 2003; Makkar *et al*., 2007).

The application of aqueous extracts of moringa resulted in an increase in the diameter of the plants which is an important criterion in determining the capacity and strength of the plant to resist breakage and lodging. The highest diameter was observed in varieties SR21 and FBC6 with a significant difference between the doses used and the varieties. However, all maize plants treated with the aqueous extract of moringa leaves had a thicker stem than the control (untreated). The greatest increase in diameter was observed with the application of the 25% and 50% doses. Similar results have been observed by Maishanu *et al.* (2017) who reported that Vigna unguiculata treated with moringa extract had a thicker stem than those treated with urea and the control. This increase in plant diameter is due to the presence of potassium present in the extract of moringa leaves (Foidl *et al.* 2001).

As for the number of leaves per plant, it has been observed that there is no difference between the 25 and 50% dose. Thus, the foliar application of the extract gives a higher number of leaves compared to the control (0%). Indeed, the activation of the production of growth hormones and cytokinins in plants treated with moringa extract could be the cause of the increase in the number of leaves. Cytokinins have the effect of retarding leaf senescence (Sanjay *et al*., 2013; Abosede and Ayodeji, 2018). Thus, the application of the extract influences the growth of maize. These growth increases are greater for the SR21 and FBC6 varieties.

Spraying the extract of moringa leaves also has a positive influence on maize yield parameters, confirming the work of Foidl *et al.* (2001) who reported that foliar spraying of certain leaves of plants with the aqueous extract of moringa leaves produced important effects such as an overall increase in plant yield estimated between 20 and 35% and higher levels of sugar and minerals. The greatest increase was obtained with the 50% dose. Indeed, the measured parameters of spice length, spice diameter and number of seeds per spice show the highest values with the dose of 50% extract of moringa leaves. The lowest value is recorded with the indicator (0%). These results corroborate those obtained by Foidl et al. (2001) who reported that foliar spraying of plants with the aqueous extract of moringa leaves produced significant effects and increased plant yield (20-35%) and higher levels of sugar and minerals in these plants. Our results also confirm the work of Fuglie (2000), who pointed out that moringa extracts, accelerated the growth of young plants, increased plant yield with the production of increasingly larger fruits. This is also due to the presence of growth factors in the leaves of Moringa oleifera Lam. (Foidl et al 2001). Indeed, these growth factors are plant hormones which are considered as growth regulators. Among these vebetal hormones we can cite auxins, gibberellins, abscisic acid, ethylene and cytokines (Prosecus, 2006). Cytokines improve food production. These results also corroborate the report by Fuglie *et al.* (2001) that the Zeatin present in Moringa leaf extract can increase crop productivity by 15% to 45%. Zeatin is one of the most common forms of cytokines naturally occurring in plants. It is a plant growth hormone from the group of cytokinins. It plays an important role in cell division and elongation (Taïz and Zeiger, 2006) which influences improvements in crop growth and yield (Price, 1985). These results corroborate those obtained by Basra (2016) who, after having tested the aqueous extract of moringa on a large number of crops (peas, okra carrot, tomatoes, millet maize, etc.), confirms an increase in economic yield of 13 to 40%. The 50% dose is the dose which has a high yield compared to the other doses (0% and 25%). As for the spice length and the number of seeds per spice, the FBC6 variety has a high yield rate. Also, the spice length does not vary depending on the variety. Indeed, all the varieties have the same spice length.

Conclusion

The purpose of this study, conducted at the CNSF, was to assess the effect of Moringa oleifera Lam leaf extract as a bio-stimulant on the growth and productivity of maize (*Zea mays* L.). The results of our study showed that without treatment with *Moringa oleifera* extract, plants of all three varieties of maize had poor growth and productivity. This confirms our first hypothesis according to which the three varieties of maize grow differently with low yields without treatment with aqueous extracts of *Moringa oleifera*.

The application of the aqueous extract of the moringa leaves to the maize plants had significant effects on the growth and yield of the 3 varieties of maize. Thus, we have an increase in seed yield, height and diameter of maize plants. The higher the application rate (50%) the more the yield increases. These results verify our second hypothesis which stipulated that the *Moringa oleifera* extracts applied to the three varieties increase their yields and that according to the doses. At the end of this study, it is recommended to apply water extracts of 50% moringa leaves two weeks after emergence and every two weeks thereafter until flowering for better maize productivity.

In view of the results obtained by this study and with the prospect of improving the yields of our crops, collaborations should be intensified between the government, farmers, institutions, extension workers and NGOs to promote and disseminate this technology through demonstrations in fields, farms and by seminars; the state must popularize the use of moringa extract which will reduce the use of inorganic fertilizers which are not always available or too expensive for poor farmers. It is important that further resspicech be undertaken in a farmer's field to confirm the results obtained. Consideration of the pest control component should be taken into account when it comes to large-scale production. Our study did not take this component into account. Finally, we believe that resspicech should focus on interactions between plant species.

References

ABDEL R.M. (2016). Impact of Moringa Leaf Extract in Productivity and Yield Quality of Garlic Plants In Sand soil. 12th International Conference of Egyptian Soil Science Society (ESSS)

ABOSEDE F. K. & AYODEYI E. SALAWU (2018). Potentials of Morina oleifera Leat Extract a Bio stimulant on the Field Performance of Sweet maize. Journal of Biology, Agriculture and Health care 8 (12) 50-56.

AGRO CONSULT Haiti SA. (April 2016). Analysis of the potential for moringa exploitation in Haiti. Final report, HAITI. 191P http://e-articles.info/e/a/title/Moringa-oleifera-::-The-Miracle-Tree accessed January 2019

BASSALER N. (2000). Maize and its futures. CNAM, Cahier du LIPS n ° 13. 47p.

BAU H. M., VILLAUME C., LIN C. F., EVRARD J., QUEMENER, B., NICOLAS J. P. & MEJEAN L. (1994). Effect of a solid-state fermentation using Rhizopus oligosporus sp. T-3 on elimination of antinutritional substances and modification of biochemical constituents of defatted rapeseed meal. Journal of the Science of food and Agriculture 65, 315-322

DIRECTORATE GENERAL OF SECTORAL STATISTICS AND STUDIES (2015). Final results of the 2014/2015 crop yspice and outlook for the food and nutritional situation. p. 73

ELOLA, (2012). Multi-local evaluation of hybrids and lines of maize (Zea mays L.). End of cycle thesis, IDR, UPB, Bobo Dioulasso, Burkina Faso, 92p.

FAHEY J.W. (2005). Moringa oleifera: A review of the Medical evidence for its nutritional, Therapeutic and prophylactic properties. Part 1. http://www.TFLjournal.org/article.php / 20051201124931586. Accessed 03/15/2010

FOILD N., MAKKAR H.P.S. and BECKER K. (2001). The potential of Moringa oleifera for agricultural and industrial uses [The potential of Moringa oleifera for agricultural and industrial uses. In: Proceedings of the international workshop on "What development potential for moringa products?]", Dar-es-Salaam, Tanzania 20p;

HIEMA S. C., June (2005). Characterization and classification of maize lines (Zea mays L.), rural development engineer thesis, Polytechnic University of Bobo Dioulasso, Bobo Dioulasso, BF.103P

HOSSAIN M.M .., MIAH, AHAMED, T. and SARMIN N.S. (2012). Study on allelopathic effect of Moringa oleifera on the growth and productivity of mungbean. International journal of Agriculture and Crop Sciences (IJACS), 4 (15), 1122-1128

HOSSAIN M.M .., MIAH G., AHMED T., & SARMIN N.S. (2012). Study on allelopathic effect of Moringa oleifera on the growth and productivity of mungbean. International Journal of Agriculture and Crop Sciences (IJACS), 4 (15), 1122-1128

HWANG I.J, SHEEN and B. MULLER (2012). Cytokinin signaling networks.Annual Review of Plant Biology, 63,353-380

KAMINSKI J., ELBEHRI A., and ZOMA J. P. (2013). Analysis of the maize sector and competitiveness in Burkina Faso: policies and initiatives for integrating small producers into the market, In: Reconstruire the food potential of West Africa, A. Elbehri (ed.), FAO / IFAD. 34P

MARCHAND J. L., BERTHAUD J., CLERGET B., DINTINGER J., REYNAUD B. and DZIDO J. L. (1997). "Maize", P. Sc. IRD / Horizon, Charrier A. (ed.), 401-427

MARTIN L. P. (1985). Moringa, ECHO technical note brochure, 22P

MVUMI C., TAGWIRA F. CHITEKA A. Z. (2013). Effect of Moringa extract on growth and yield of maize and common beans. Greener J. Agri. Sci, 3 (1): P55-62

MVUMI C., TAGWIRA F. and ALBERT Z. C. (September 2012). Effect of Moringa extract on growth and tield of tomato, resspicech article, Mutare, Zimbabwe. 5P

OUBDA W. Y. C. (April 2014). Evaluation of stable lines obtained in varieties of intermediate, spicely and extra spicely cycle maize popularized in Burkina Faso, memory, IDR, UPB, Bobo Dioulasso. 100P

PERRIOT B., (April 2020). Should it be treated in the morning, evening or night? resspicech article edited at Institut du Plant

SAHEED M. KALEEM A. and MUSHTAQUE K. (2001). Response of maize (Zea mays) NP fertilization under Agro-climatic condition of rawalokot Azad Jummu and Kashmir. Pakistan journal of biological science 4 (8): 946-952 2001

SAM J.B., July (2017). Study of the effect of pretreatments on the germination and growth of Zanthoxylum zanthoxyloides (Lam.) Zepernick and Timler from four provenances in the nursery. End of cycle memory, ENEF, Bobo Dioulasso. 41p

SANJAYS, SATYA P.M., PANKAJ S. and DAS R. (2013). Moringa oleifera Leaf Extract as Biostimulant for increasing Pea yield. Malaysian Forester 139 (6), 562-563

SANOU A. (June 2011). Creation and evaluation of hybrids and lines of maize as part of an intensification of maize cultivation in Burkina Faso. End of cycle memory, IDR, UPB, Bobo Dioulasso, BF.105P

SEKONE L. P. (September 2006). Ethnopharmacology applied to medicinal plants and traditional pharmacopoeias. Brief, Burkina Faso.71P

SEKONE L. P. (September 2006). Moringa oleifera or the tree of life, memory for validation of training, BF.71P

TRAORE G.D. S. (June 2016). Analysis of the adaptation of maize (Zea mays L.) to cultivation in the cold dry season in Burkina Faso, end-of-cycle memory, IDR, UBP, Bobo Dioulasso. 63P

ZOMA W.O. (2010). Improvement of the hope maize variety for the intensification of its cultivation. End of cycle thesis, IDR, UPB, Bobo Dioulasso, Burkina Faso. 75P.