

Evaluation of the effect of three types of fertilizer on the agronomic potential of a hybrid variety of maize (*Zea mays* L.), grown in Korhogo commune in Côte d'Ivoire

Abstract

Objectif : Maize is a crop whose grains are involved in the diet of West African populations, and also in the food of the populations of the Korhogo region. However, the yield of this crop is still low in the region. The study was initiated to help increase maize production by assessing the effects of different types of mineral and organic fertilizers on maize yield. The study was conducted, during 6 months, on the experimental site of the University Peleforo Gon Coulibaly of Korhogo, located in Northern of Côte d'Ivoire.

Methodology : The device use dis in a Fisher block, comprising 4 treatments and 4 replicates. The 4 treatments studied included a mineral fertilizer Yara Mila Actyva, composition NPK 23-10-5 + 3S + 2MgO + 0.3 Zn, two types of organic fertilizer (organic foliar fertilizer Bio Deposit Elixir or BDE and organic fertilizer Phytobiologique Aval or EPA) and the control without fertilizer.

Results and conclusion : The results obtained showed that all production characteristics and yield were improved by the different types of fertilizer supplied. Mineral fertilizer, with an average yield of $12,373 \text{ kg ha}^{-1}$, gave the highest yield. Organic fertilizers, with yields of $6,560 \text{ kg ha}^{-1}$ for PBA and $9,153 \text{ kg ha}^{-1}$ for BDE, significantly improved maize production compared to the control yield ($5,972 \text{ kg ha}^{-1}$). In a context where the high price of mineral fertilizers is very often a hindrance to the intensification of maize cultivation, this study is a contribution to fertilization through the use of organic fertilizers and adapted to the socio-economic conditions of the region, knowing the low income of the peasants.

Key words: Fertilization, Korhogo, mineral fertilizer, organic fertilizer, yield, *Zea mays* L.

1. INTRODUCTION

Due to rapid population growth and the consequent food needs, agricultural production must increase significantly in order to feed the world's population. Fallows and natural inputs of organic matter no longer allow the necessary increase in agricultural production, including that of corn. The national average production was estimated in 2017 at 650,000 tons, on an average surface of about 300,000 ha. Corn is one of the staples of Ivorian populations,

33 including Korhogo. It is fed to people, in the form of grain, cooked, grilled, salad, or in soup
34 [1].

35 The low productivity of this crop encountered in the Korhogo region is mainly due to the
36 sharp decline in soil fertility and rainfall. Crop productivity can then be increased either by
37 improving yields or by increasing the area of land developed for agriculture. However, in the
38 current context of desertification, deforestation and urbanization, few regions of the world are
39 able to support a significant increase in areas devoted to agriculture [2].

40 The need to improve crop yields and productivity on existing farmland becomes a primary
41 and obvious objective. Only the improvement of farming techniques (including the provision
42 of organic and chemical fertilizers) and the selection of more productive varieties open
43 perspectives in this direction. But in this context of food crops, the maintenance of soil
44 fertility will be the keystone [3].

45 In most countries South of the Sahara, the increase in population pressure has led to an
46 intensification of agricultural practices and an extension of cultivated areas which has
47 resulted in a reduction of fallow periods. This not only predisposes soil to erosion, but also
48 causes rapid depletion of nutrients, including potassium, nitrogen, and phosphorus [4]. On the
49 agricultural side, the consequences translate into low yields for the main food crops. On the
50 other hand, the more productive improved varieties are generally criticized for being very
51 demanding in terms of specific mineral elements and pesticides which are often difficult to
52 acquire.

53 It is now realized that it is more advantageous for developing countries to import fertilizer
54 quantities in order to raise the yield levels of their crops rather than having to buy cereals in
55 international markets to fill food deficits [5]. The use of fertilizers is therefore a key factor in
56 the modernization of agriculture in developing countries. The other advantage of fertilizers is
57 that they not only improve yield but also crop residues (biomass) that is used as organic
58 fertilizer by the previous crop [6]. According to Nyembo [7], in large farms, with the use of
59 improved varieties and the use of mineral fertilization, yields of around 4,000 to 6,000 kg ha⁻¹
60 are achieved, compared to 800 kg ha⁻¹ in peasant farms without fertilization.

61 The general objective of this study is to evaluate the behavior of an improved variety of
62 maize with respect to a mineral fertilizer and two types of organic fertilizer. The objectives
63 pursued by this research are the determination of the type of chemical and organic fertilizer
64 best adapted to maize cultivation, allowing a better reaction of the maize variety. Thus, the
65 following assumptions were made: (i) the use of chemical and organic fertilizers improves

the development and yield of maize, (ii) the maize variety would act differently with respect to the three types of fertilizer.

2. Material and methods

2.1. Study area

The study was conducted in Korhogo district located in northern Côte d'Ivoire, whose geographical coordinates are 9 ° 26' North longitude and 5 ° 38' West latitude. The climate of the zone, Sudanese type, is characterized by an alternation of two seasons. A long dry season, from October to May, precedes the rainy season, marked by two rainy peaks, one in June and the other in September. The area is also characterized by average temperatures ranging between 24 and 33 °C and a monthly average humidity of 20%. The annual rainfall is between 1,100 and 1,600 mm and the duration of insolation is 2,600 hours per year.

The soil is of tropical ferruginous type, formed on granite who's leaching more or less intense, has reduced the fertility. The relief is generally flat and scattered in places by inselbergs. The soils of the region contain more than 10% clay and silt, more than 40% organic matter, the C/N ratio varying from 7 to 13, the cation exchange capacity of less than 24 cmol kg⁻¹ and saturation rate below 50% and a pH of 5.5 [8].

2.2. Plant material

The plant material used was a hybrid variety of maize, called "Komsaya". This variety of maize was released by callivoire (seed production company) and is characterized by the yellow color of the grains produced and a yield of up to 4 to 6 t ha⁻¹, under the best growing conditions. It usually produces on average two ears per foot. The average length of its cycle is about 90 days. The grains produced by this variety are particularly rich in lysine, tryptophan and provitamin A. This variety is most often recommended for feeding children [9].

2.3. Fertilizer products

Fertilizer products consisted of two different types of organic fertilizer and a mineral fertilizer :

- a mineral fertilizer, called "Yara Mila Actyva" or (YMA), existing in the granulated form and of composition NPK 23-10-5 + 3S + 2MgO + 0.3 Zn;

- a foliar organic fertilizer, called "Bio Deposit Elixir" (BDE), used in liquid form and composed of sapropile (mud organic substances) and peat (product of the decomposition of herbaceous plants in stagnant water);

- an organic fertilizer of plant origin, called "Phytobiological Aval Fertilizer" (EPA), found in the powdery form. It consists of organic substance of vegetable origin.

2.4. Methods

2.4.1. Experimental device and treatments and their application

The experimental setup consisted of Fischer blocks, completely randomized, with 4 treatments and 4 blocks. The study consisted of 16 elementary plots. Each elementary plot consists of 32 maize plants, transplanted on 4 lines of 8 girdles, at intervals of 0.30 m x 0.80 m. The elementary plots and blocks were, respectively, separated by a distance of 1 m and 1 m.

The 4 treatments studied are the following:

- T0: control without fertilizer input;
- T1: organic foliar fertilizer "Bio Deposit Elixir" or BDE;
- T2: organic fertilizer Phytobiological Aval or EPA;
- T3: mineral fertilizer Yara Mila Actyva or YMA.

These different treatments were applied during the vegetative phase of maize. The period of application and the doses used depend on the type of fertilizer.

The solution of organic foliar fertilizer (BDE) (T1) was obtained by a mixture of 12 ml of this fertilizer and 20 l of water. This mixture was applied on the whole aerial part of the corn plants. A total of 4 applications were made during different periods of the vegetative phase. These periods are the 7th, 21st, 35th and 49th days after sowing (DAS).

The Phytobiological Organic Fertilizer Aval (T2) was applied in a crown around each maize plant. Two applications, at different doses, were made during the vegetative phase. The first application, with a dose of 30 g/plant, was carried out on the 20th DAS and the second took place on the 40th DAS, with a dose of 15 g/plant.

Mineral fertilizer Yara Mila Actyva (T3) was buried at a depth of 2 cm and 5 cm around each plant. The first application was made, with a dose of 15 g/plant, the 15th DAS and the second was carried out the 30th DAS, at a dose of 30 g/plant.

The doses of the different types of fertilizers, used during this study, are those which are vulgarized in peasant.

2.4.2. Measured parameters

Various morphological and yield parameters were measured per basal plot during the study.

The height of each plant was evaluated by measuring its size, from the collar to the last newly opened leaf (arrow). The neck diameter was obtained by measuring the circumference of the neck of each plant. The number of leaves issued per plant was obtained by counting all the leaves formed. The leaf area or wingspan was determined by measuring the diameter of the crown formed by the leaves on either side of the main stem. The number of senescent leaves was estimated by counting senescent leaves carried per plant.

The number of ears per plant was determined by counting all the ears formed by each foot. The length of the ears was obtained by measuring the length of each ear produced. The diameter of the ears was determined from the circumference of the base of each ear. The dry weight of each ear was obtained by weighing each ear after removal of the spathes. The number of grains per ear was estimated by counting all the grains carried by each ear, after ginning. The weight of the grains per ear was determined by weighing all the grains carried by each ear. The weight of 1000 grains was obtained by weighing 1000 grains, after ginning and counting. The weight of the grain-free ear was determined by weighing. The yield ($R \text{ ha}^{-1}$) was determined from the following relationship:

$R = NE * WE * D$, with

R: the yield in tons/ha

NE: the total number of ears per hectare;

WE: Weight of each ear in kg;

D: Density of plantation whose standard is 100,000 grains/ha or 20 kg of grains/ha.

2.5. Data processing and analysis

The data, collected and recorded using the Excel spreadsheet, was subjected to an analysis of variance using the XLSTAT version 7.5 software. The significance level of differences between means was estimated using the Duncan test at the 5% threshold. Correlations, Principal Component Analysis (PCA) and Ascending Hierarchical Classification (AHC) were performed using the Statistica Version 7 software.

3. RESULTS AND DISCUSSION

3.1. Results

3.1.1. Effect of different types of fertilizers on morphological parameters

Table 1 presents the average values of all the growth parameters obtained after adding different types of organic and mineral fertilizers.

At the height of maize plants, analysis of the variance **did** not reveal any difference between the averages obtained. These averages ranged from 92.9 cm (T0) to 115.4 cm (T3). The application of the different types of fertilizer did not have any effect on the improvement of the height of the plants.

In the analysis of this table 1, which presents the results of the mean diameters at the collar of the plants, differences were observed between the averages of the different treatments applied. The results obtained, with these different treatments, reveal the constitution of two homogeneous groups. **The first group consists of the averages obtained with the T3 treatment. With an average of 16.1 mm, the effects of mineral fertilizer were the highest. This treatment has the most improved collar diameter of the plants. The second group consists of the T0, T1 and T2 treatments whose effects in improving the neck diameter were the weakest.** These values varied between 13.3 mm (T0) and 14 mm (T2). With regard to the size of the plants, variance analysis revealed differences between the averages obtained with the different types of fertilizer applied. These results revealed the constitution of two homogeneous groups. The first group consists of averages recorded with the mineral fertilizer (108.9 cm). This treatment gave the highest average. The second group consists of the averages obtained with the organic fertilizers BDE (102.4 cm), the organic fertilizer PBA (96.4 cm) and the control (96.7 cm). These three treatments recorded the lowest averages.

The average results in number of leaves issued are also presented in Table 1. The analysis of the variance did not reveal any difference between the averages obtained with the different treatments applied. These averages ranged from 9.9 leaves (T2) to 10.9 leaves (T3). The application of the different types of fertilizer had no influence on the emission of corn leaves during this study.

As for the number of senescent leaves, presented in Table 1, the analysis of the variance revealed differences between the averages obtained with the different treatments applied. Leaf senescence is linked to the application of different types of mineral and organic fertilizers. The results obtained show the constitution of two homogeneous groups. The first group is formed by the averages obtained with the T3 treatment whose number of senescent leaves was the lowest. The second group, with the highest averages, is the averages obtained with T0 (1.9 leaves), T1 (2.5 leaves) and T2 (2 leaves) treatments.

Table 1. Mean values of maize morphological parameters for different applied fertilizers

Treatements	Height of plant (cm)	Neck diameter (mm)	Wingspan of plant (cm ²)	Number of leaves issued	Number of senescent leaves
T0 (control)	92.9 a	13.3 b	96.7 b	9.8 a	1.9 a
Organic fertilizer BDE	108.4 a	14.0 b	102.4 b	10.4 a	2.5 a
Organic fertilizer PBA	98.6 a	13.4 b	96.4 b	9.9 a	2.0 a
Mineral fertilizer YMA	115.5 a	16.1 a	108.9 a	10.9 a	0.3 b

In the same column, the values followed by the same letter are not significantly different at the 5% threshold, Duncan's test

3.1.2. Effect of different types of fertilizers applied on production parameters

The averages of the production parameters obtained after adding the different types of fertilizer are presented in Table 2. An analysis of this table shows that differences were observed between the averages of the number of grains per head, the weight of 1,000 grains, the weight of the grainless ear, the length of the ears, the diameter of the ears, the number of ears per plant and the yield obtained with the different treatments. However, in terms of the weight of the straw and aboveground biomass, no difference was observed between the averages obtained for the different types of fertilizer applied.

In terms of number of kernels per ear, yield, ear length and ear diameter, the results showed the formation of three homogeneous groups. With average values of 476 grains per ear, 12,373 kg ha⁻¹ (yield), 16.6 cm (ear length) and 13.7 cm (ear diameter), the first group consists of the averages obtained with the use of YMA mineral fertilizer. This treatment (mineral fertilizer) made it possible to obtain the highest averages. The second group consists of the averages obtained with organic fertilizers (BDE and PBA), at the level of these different measured parameters. As for the third group, it is formed by averages obtained with the control without organic fertilizer and mineral. This treatment gave the lowest averages for these different parameters. These averages were 269 grains, 5,972 kg ha⁻¹, 11.2 cm and 11.4

cm, respectively, for the number of kernels per head, yield, ear length and ear diameter (Table 2).

The results obtained also showed the formation of two homogeneous groups in terms of the weight of the grainless ear and the number of ears per plant.

At the level of the number of ears per plant, the first group, with an average of 2.05 ears, consists of the averages obtained with the mineral fertilizer. This treatment gave the highest average. The second group, with the lowest averages, is formed by those obtained with the other three treatments (control without fertilizer, organic fertilizer BDE and organic fertilizer PBA). These averages ranged from 1.05 to 1.15 ear per plant.

As for the weight of the grainless cob, the first group consists of the averages obtained with the mineral fertilizer and the organic fertilizer BDE. These averages were 148 g (mineral fertilizer) and 111 g (organic BDE fertilizer). The second group consists of the averages obtained with the organic fertilizer PBA (84 g), the organic fertilizer BDE (111 g) and the control without fertilizer (72 g). These values were the lowest (Table 2).

In terms of the weight of straw and aboveground biomass, the results showed no difference between the averages of the different treatments applied. These average values varied between 1.2 g (organic fertilizer) and 1.7 g (mineral fertilizer) for the weight of straw and 1.3 g (organic fertilizer PBA) to 1.9 g (mineral fertilizer) for aerial biomass.

3.1.3. Study of correlations between variables

Correlations between the different parameters for the maize variety were studied. Table 3 presents the Pearson correlation matrix between these studied parameters. The analysis in this table reveals the existence of positive and significant correlations between the parameters. These correlations are as follows:

- the number of kernels per head and the yield ($R^2 = 0.960$), the weight of the grainless cob ($R^2 = 0.973$), the length of the cob ($R^2 = 0.992$), the diameter of the cob ($R^2 = 0.984$);
- the yield and weight of 1000 grains ($R^2 = 0.956$), the weight of the grainless cob ($R^2 = 0.998$), the length of the cob ($R^2 = 0.983$), the collar diameter of the plants ($R^2 = 0.972$);
- the weight of 1,000 grains and the weight of the grainless cob ($R^2 = 0.962$);
- the weight of the grainless ear and the length of the ears ($R^2 = 0.989$), the neck diameter of the seedlings ($R^2 = 0.967$);
- the length of the ears and the diameter of the ears ($R^2 = 0.954$), the neck diameter of the plants ($R^2 = 0.976$);

260 - the neck diameter of the plants and the number of ears per plant ($R^2 = 0.960$).
261 The number of senescent leaves is negatively correlated with the number of ears per plant (R^2
262 = -0.971).
263 All the parameters studied (number of grains per ear, yield, weight of 1,000 grains, weight of
264 the grainless ear, length of the ear, diameter of the ear, diameter at the collar of the plants,
265 number of senescent leaves and the number of ears per plant) establish correlations whose
266 distribution is shown in Fig. 1.

267 **Table 2. Mean values of maize production parameters according to applied fertilizers**

Treatements	Number of grains per ear	Yield (kg/ha)	Weight of 1000 grains (g)	Weight of grains free ear (g)	Weight of straw (kg)	Aboveground Biomass (kg)	Length of éar (cm)	Diameter of ear (mm)	Number of ears per plant
T0 (control)	269 c	5,972 c	107 d	72 b	1.3 a	1.4 a	11.2 c	11.4 c	1.2 b
Organic fertilizer BDE	372 b	9,153 b	158 b	111 ab	1.2 a	1.4 a	13.5 b	12.8 ab	1.1 b
Organic fertilizer PBA	342 bc	6,560 bc	121 c	84 b	1.2 a	1.3 a	12.4 bc	12.6 b	1.1 b
Mineral fertilizer YMA	476 a	12,373 a	172 a	148 a	1.7 a	1.9 a	16.6 a	13.7 a	2.1 a

268 *In the same column, the values followed by the same letter are not significantly different (Duncan, 5%)*

269

270 **Table 3. Correlations between the parameters studied**

Parameters studied	Number of grains/ear	Yield	Weight of 1000 grains	Weight of ear free grains	Length of ear	Ear diameter	Neck diameter	Number of senescent leaves	Number of ears/plant
Number of grains/ear	1								
Yield	0.960	1							
Weight of 1000 grains	0.926	0.956	1						
Weight of ear free grains	0.973	0.998	0.962	1					
Length of ear	0.992	0.983	0.926	0.989	1				
Ear diameter	0.984	0.908	0.915	0.930	0.954	1			
Neck diameter	0.940	0.972	0.862	0.967	0.976	0.866	1		
Number senescent leaves	-0.742	-0.742	-0.520	-0.733	-0.792	-0.637	-0.879	1	
Number of ears/plant	0.829	0.869	0.686	0.856	0.884	0.724	0.960	-0.971	1

271 *In bold, significant values (off diagonal) at the alpha threshold = 0.05 (bilateral test)*

3.1.4. Distribution of treatments and parameters studied in the plan formed by the axes

The distribution of applied treatments and the different parameters studied in the **plan** formed by the axes are presented in Figure 1. Explaining nearly 98.32% of the variability expressed, these are the first two axes of the principal component analysis which have been taken into account. On the F1 axis that has absorbed the highest percentage of variability (89.84%), the variables are the weight of 1,000 grains, the diameter of the ear, the number of grains per ear, the weight of the ear. grain-free ear, yield and length of ear. These parameters were positively correlated to the F1 axis.

The second axis, which absorbed about 8.48% of the variability, is defined on the positive side by the number of senescent leaves and on the negative side by the neck diameter of the plants and the number of ears per plant.

According to the Biplot plan (Figure 1), each of the four treatments studied is located in a quarter of a **plan**, drawn by the first two axes. The treatments using organic fertilizers (BDE and PBA) are located in the same quarter of **plan**, while the treatments with the mineral fertilizer and the witness each occupy a quarter of plan. The quarter of **plan** representing the control without fertilizer does not include any parameters studied. The organic fertilizers BDE and PBA belong to the same quarter of **plan** with the parameter number of senescent leaves. As for the mineral fertilizer, Figure 1 shows, with the exception of the number of senescent leaves, a comparison between this treatment and all the other parameters studied

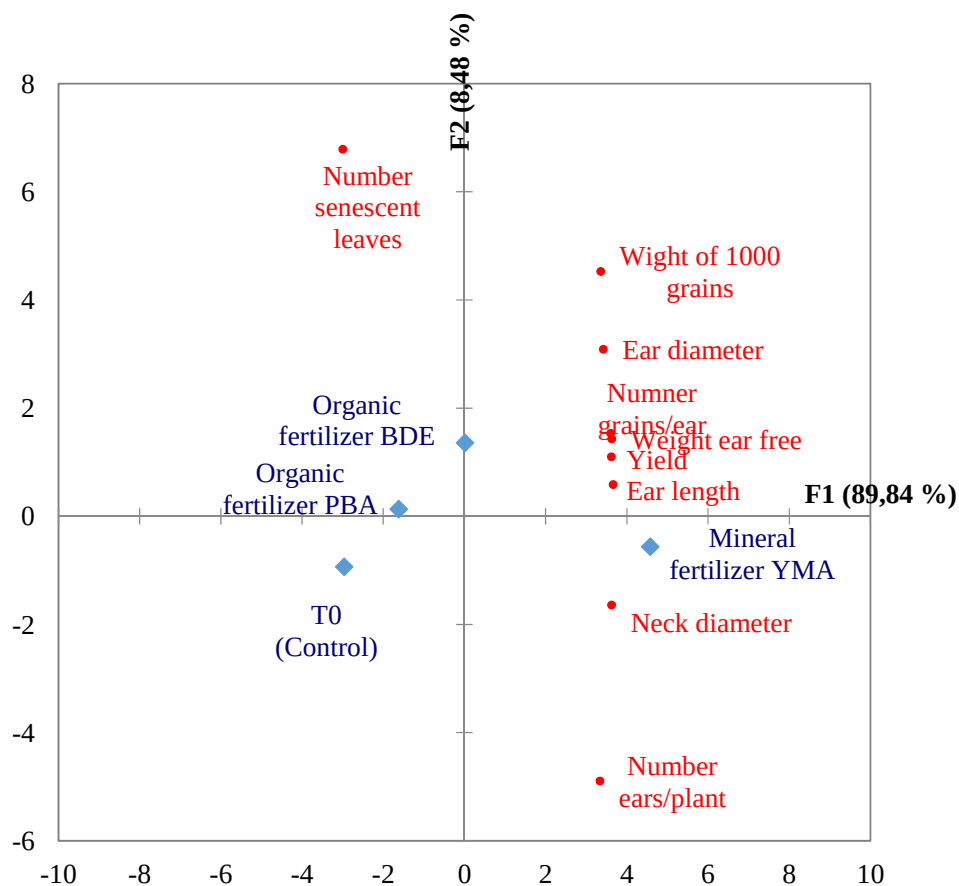


Fig. 1. Distribution of the treatements and the parameters studied in the Biplot plan

3.2. Discussion

This study demonstrated the ability of mineral and organic fertilizers to enhance growth, fruiting and maize yield on ferruginous soil. These results are similar to those obtained in other regions of sub-Saharan Africa, notably, on maize in Nigeria [10] and on the same crop in Cameroon [11], showing that the overall trend in the evolution of soil properties tested and yield was up compared to control treatment and mineral and organic fertilization.

In the experiment, we obtained an improvement of the vegetative parameters as well as those of the production, with the contribution of the different types of fertilizers. Depending on the initial soil composition of the study site, fertilizer is therefore important for improving growth and production characteristics [12, 13]. Mineral and organic manures had a significant influence on the growth and development of the maize plant vegetative system.

Comparison of the different types of fertilizer brought between them shows that the mineral fertilizer induced a higher growth of the neck diameter and the scale of the plants which are

excellent indicators of the vegetative development. This evolutionary trend according to the type of fertilizer is, consequently, observed on the general growth of the plants compared to the control and the organic fertilizers (BDE and PBA). These results show that there is a good response of maize plants to mineral fertilization on the ferruginous soils of Korhogo.

Indeed, these soils have a low potential for supplying essential mineral elements for maize growth and development. The mineral nutrition of the plants is thus insufficient. The contributions of mineral fertilizer fill this mineral deficiency and ensure adequate nutrition of the plants. The nutrient uptake by plants is proportional to its availability in the soil solution and the demand expressed by the terminals of actively growing shoots [14]. The levels of the elements in the plants are most often related to their concentrations in the soil solution and certain environmental factors [15]. The mineral fertilizer brought would have left in the soil so many mineral elements which allowed a favorable mineral nutrition and a good growth of the maize plants.

In general, the study on the comparison of the effects of fertilizers on aerial biomass production by maize plants shows that the control without fertilizer and organic fertilizers give the lowest yields. Soil poverty could be the main reason for these results. These results reflect the need for mineral fertilization to obtain good yields on these types of soils.

Nutrients N, P and K would play important roles in plant development and growth. The insufficiency or absence of these elements causes yield reductions. Among the mineral elements, nitrogen would influence plant growth more. Nitrogen is the main stimulant of plant growth [16] and any form of life cannot grow and function without acquiring nitrogen in acceptable form [16]. In addition, application of chemical fertilizers that provide nutrients such as nitrogen significantly increases maize biomass production [17]. In addition, the nutrients released by mineral fertilizers are directly and easily used by plants [16].

The low production of the control and organic fertilizers can be attributed to the characteristic factors of acid soils: acid pH, Al and Mg toxicity, nutrient deficiencies (Ca, Mg, P, K and B) and slow release of these mineral elements [4]. In addition, on the plots, the absence of nutrient inputs is accompanied by a loss of organic matter and nutrients, soil acidification, a reduction in biomass and microbial activity, insolubilization of phosphorus which together contribute to the significant decrease in crop yields [18]. The slow release of mineral elements by organic fertilizers and the short corn crop cycle (about 90 days) would explain the identical production of above-ground biomass by organic fertilizers and control without fertilizer.

In our study, there was a significant improvement in production characteristics and maize grain yield, with a supply of mineral fertilizer and organic fertilizer compared to the control without fertilizer. These results show that maize has a good response to mineral and organic fertilization on ferruginous soils in the Korhogo region.

The production characteristics of the number of grains per ear, the weight of 1000 grains, the weight of the grainless ear, the length of the ear, the diameter of the ear and the number of ears per plant and Yield was significantly improved by mineral fertilizer (Yara) compared to organic fertilizers.

Chemical fertilizer input significantly increased corn yield compared to control plots and organic fertilizers.

The desirability of using mineral fertilizers is revealed here, in that almost all agronomic parameters have increasing values with the increase of the fertilizer dose. This shows that the study site values mineral fertilizers better according to the initial chemical composition of the soil [12, 13].

The beneficial effects of chemical fertilization through agriculture have been demonstrated by many authors [19, 3]. Mineral fertilizers have greater agronomic efficiency because their nutrients are available and easily absorbed by crops compared to organic fertilizers. This gradual increase in the improvement of production parameters by mineral fertilizer is largely due to its availability of mineral elements which create the best mineral nutrition conditions for maize plants.

The addition of mineral fertilizers significantly increases pollen production [20]. Which improved the rate of fertilization of flowers. The mineral fertilizer, judiciously used, makes it possible to increase crop yields in large proportions. As such, it is a determinant of agricultural yields [21]. The application of mineral fertilizers almost always improves yield [22]. Different studies have shown that nitrogen fertilization accelerates plant growth and increases above-ground biomass and yield [23].

Mineral fertilizers provide high yields and good quality of grain corn and forage corn. However, these fertilizers can have negative impacts on the environment if their use is not optimized [24, 25]. It is therefore important to measure their effectiveness according to different cultural practices and representative pedoclimatic conditions.

The study also showed that all production characteristics and yield were significantly improved by organic fertilizer compared to control without fertilizer.

Organic fertilizer BDE and PBA had a much greater influence on maize plant production in the field, compared to the control without fertilizer, the improvement of all measured yield

characteristics. This is explained by the amount of mineral elements available to the plants. In fact, organic fertilizers are an important source of mineral elements.

The beneficial effects of organic fertilizers on crop production have been proven by many researchers and it has been shown that the application of organic fertilizers improves the physical, chemical and biological properties of the soil [26, 27]. Nutrients in organic fertilizers increase crop yield [28]. Some authors reported that composted organic fertilizer applications as a source of nutrients affected corn grain yield, indicating that the fertilizer value of these fertilizers was comparable to that of mineral fertilizers [29, 30]. The yields of vegetable crops have been significantly increased by sewage sludge application and that a difference was observed with other organic fertilizer treatments [31]. In addition, the application of human faeces as organic fertilizer recycles nutrients and eliminates the need for chemical fertilizers in cropland [32]. The application of recycled organic fertilizers on agricultural soils improves the physical, chemical and biological properties of the soil because they contain organic matter and plant nutrients [33]. The addition of organic fertilizers leads to the acceleration of microbial biomass activity and the improvement of the availability of organic matter to soil micro-organisms [34]. The mineralization of organic matter by the acceleration of microbial biomass activity, would be favored by the increase of nitrogen content in organic fertilizers and soil pH [35, 34]. The use of organic amendments is due to the fact that they play an important role on various soil properties [36, 2, 37]. Indeed, local resources such as organic fertilizers and mineral fertilizers applied to poor tropical and acidic soils provide the nutrients needed for plant nutrition and growth, and therefore increase crop yields.

The control without fertilizer generally had much smaller effects on the improvement of all measured production parameters. This may be due to the fact that the soils of the control would contain very little nutrients necessary to improve the production characteristics and yield of maize plants in the field. The low production of the control soils can be attributed to the characteristic values of the soils of the region, marked by their poverty in mineral elements. The absence of fertilizer inputs and the lack of mineral elements are accompanied by a loss of organic matter and nutrients, soil acidification, a reduction in biomass and microbial activity. [38].

The results, thus obtained, showed the importance of organic and mineral fertilization for maize cultivation, through an improvement of production growth parameters, on the soils of the Korhogo region. Failing to apply the mineral fertilizer, for the cultivation of corn, organic fertilizers BDE and PBA could be used because of their efficiency on the yield.

4. CONCLUSION

At the end of this study, it appears that the mineral fertilizer (Yara) had the highest effects in improving the production of maize plants. Organic fertilizer inputs, namely PBA and BDE, also improved all the measured yield characteristics compared to the control.

The study comparing the effects of mineral and organic fertilizers in maize cultivation contributes to the understanding of the importance of organic fertilization, which is a value to be sought to replace mineral fertilizers whose price has often been decried by small producers. Such a study becomes unavoidable in the particular culture conditions of climate change, drastically influencing the yield of crops.

The results of this study showed improved production characteristics and yield by mineral fertilizer and organic fertilizers. It appears necessary to continue this study in all the agroecological zones of maize cultivation, and by varying the doses used, with a view to an essential adjustment to popularized fertilizers, for a determination of economically profitable doses. These results will make it possible to optimize the use of organic and mineral fertilizers under maize cultivation in Côte d'Ivoire.

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