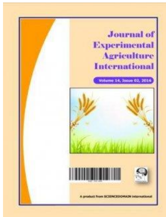

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Evaluation of the Effect of Three Types of Fertiliser on the Agronomic Potential of a Hybrid Variety of Maize (*Zea mays* L.), Grown in Korhogo Commune in Côte d'Ivoire

Siené Laopé Ambroise Casimir[1], Coulibaly Lacina Fanlégué[1], Kouamé Konan[1*], Conde Mariame[1], Koné Mamadou[1] and Aké Séverin[2]

[1]Plant Physiology Laboratory, UFR Biological Sciences, Peleforo Gon Coulibaly University, BP1328 Korhogo, Côte d'Ivoire.
[2]Plant Physiology Laboratory, UFR Biosciences, Félix Houphouët-Boigny University, 22 BP 582 Abidjan 22, Côte d'Ivoire.

Authors' contributions

This work was carried out in collaboration between all authors. Author SLAC designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors CLF and KK managed the analyses of the study. Authors CM and KM managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Objective: 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 fertilisers on maize yield. The study was conducted, for 6 months, on the experimental site of the University Peleforo Gon Coulibaly of Korhogo, located in the north of Côte d'Ivoire.

**Corresponding author: E-mail: konanaubino@gmail.com;*

Methodology: The device used is in a Fisher block, comprising 4 treatments and 4 replicates. The 4 treatments studied included a mineral fertiliser Yara Mila Actyva, composition NPK 23-10-5 + 3S + 2MgO + 0.3 Zn, two types of organic fertiliser (organic foliar fertiliser BioDeposit Elixir or BDE and organic fertiliser Phytobiologique Aval or EPA) and the control without fertiliser.
Results and Conclusion: The results obtained showed that all production characteristics and yield were improved by the different types of fertiliser supplied. Mineral fertiliser, with an average yield of 12,373 kg ha^{-1}, gave the highest yield. Organic fertilisers, with yields of 6,560 kg ha^{-1} for PBA and 9,153 kg ha^{-1} for BDE, significantly improved maize production compared to the control yield (5,972 kg ha^{-1}). In a context where the high price of mineral fertilisers is very often a hindrance to the intensification of maize cultivation, this study is a contribution to fertilisation through the use of organic fertilisers and adapted to the socio-economic conditions of the region, knowing the low income of the peasants.

Keywords: Fertilisation; Korhogo; mineral fertiliser; organic fertiliser; yield; Zea mays L.

1. INTRODUCTION

Due to rapid population growth and the consequent food needs, agricultural production must increase significantly 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 average national output 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, including Korhogo. It is fed to people, in the form of grain, cooked, grilled, salad, or in soup [1].

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

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

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

It is now realised that it is more advantageous for developing countries to import fertiliser quantities to raise the yield levels of their crops rather than having to buy cereals in international markets to fill food deficits [5]. The use of fertilisers is, therefore, a key factor in the modernisation of agriculture in developing countries. The other advantage of fertilisers is that they not only improve yield but also crop residues (biomass) that is used as organic fertiliser by the previous crop [6]. According to Nyembo [7], in large farms, with the use of improved varieties and the use of mineral fertilisation, yields of around 4,000 to 6,000 kg ha^{-1} are achieved, compared to 800 kg ha^{-1} in peasant farms without fertilisation.

The general objective of this study is to evaluate the behaviour of an improved variety of maize with respect to mineral fertiliser and two types of organic fertiliser. The objectives pursued by this research are the determination of the type of chemical and organic fertiliser best adapted to maize cultivation, allowing a better reaction of the maize variety. Thus, the following assumptions were made: (i) The use of chemical and organic fertilisers improves the development and yield of maize, (ii) The maize variety would act differently with respect to the three types of fertiliser.

2. MATERIALS 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 characterised 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 characterised 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 characterised by the yellow colour 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 Fertiliser Products

Fertiliser products consisted of two different types of organic fertiliser and mineral fertiliser:

- a mineral fertiliser, 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 fertiliser, 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 fertiliser of plant origin, called "Phytobiological Aval Fertiliser" (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 randomised, 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 fertiliser input;
- T1: Organic foliar fertiliser "Bio Deposit Elixir" or BDE;
- T2: Organic fertiliser Phytobiological Aval or EPA;
- T3: Mineral fertiliser 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 fertiliser.

The solution of organic foliar fertiliser (BDE) (T1) was obtained by a mixture of 12 ml of this fertiliser and 20 l of water. This mixture was applied to 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 Fertiliser 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 fertiliser 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 fertilisers, used during this study, are those which are vulgarised 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 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 fertilisers on morphological parameters

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

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 fertiliser 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 fertiliser 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). Concerning the size of the plants, variance analysis revealed differences between the averages obtained with the different types of fertiliser applied. These results revealed the constitution of two homogeneous groups. The first group consists of averages recorded with the mineral fertiliser (108.9 cm). This treatment gave the highest average. The second group consists of the averages obtained with the organic fertilisers BDE (102.4 cm), the organic fertiliser PBA (96.4 cm) and the control (96.7 cm). These three treatments recorded the lowest averages.

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

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 fertiliser BDE	108.4 a	14.0 b	102.4 b	10.4 a	2.5 a
Organic fertiliser PBA	98.6 a	13.4 b	96.4 b	9.9 a	2.0 a
Mineral fertiliser 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

Table 2. Mean values of maize production parameters according to applied fertilisers

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 fertiliser 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 fertiliser 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 fertiliser 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

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

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**

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

The average results in a 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 fertiliser 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 fertilisers. 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.

3.1.2 Effect of different types of fertilisers applied on production parameters

The averages of the production parameters obtained after adding the different types of fertiliser 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, regarding the weight of the straw and aboveground biomass, no difference was observed between the averages obtained for the different types of fertiliser applied.

Regarding the 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 fertiliser. This treatment (mineral fertiliser) made it possible to obtain the highest averages. The second group consists of the averages obtained with organic fertilisers (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 fertiliser 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 regarding 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 fertiliser. 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 fertiliser, organic fertiliser BDE and organic fertiliser 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 fertiliser and the organic fertiliser BDE. These averages were 148 g (mineral fertiliser) and 111 g (organic BDE fertiliser). The second group consists of the averages obtained with the organic fertiliser PBA (84 g), the organic fertiliser BDE (111 g) and the control without fertiliser (72 g). These values were the lowest (Table 2).

Regarding 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 fertiliser) and 1.7 g (mineral fertiliser) for the weight of straw and 1.3 g (organic fertiliser PBA) to 1.9 g (mineral fertiliser) 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);
- the neck diameter of the plants and the number of ears per plant (R^2 = 0.960).
- The number of senescent leaves is negatively correlated with the number of ears per plant (R^2 = -0.971).

All the parameters studied (number of grains per ear, yield, weight of 1,000 grains, weight of the grainless ear, length of the ear, diameter of the ear, diameter at the collar of the plants, number of senescent leaves and the number of ears per plant) establish correlations whose distribution is shown in Fig. 1.

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 Fig. 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 the ear. These parameters were positively correlated to the F1 axis.

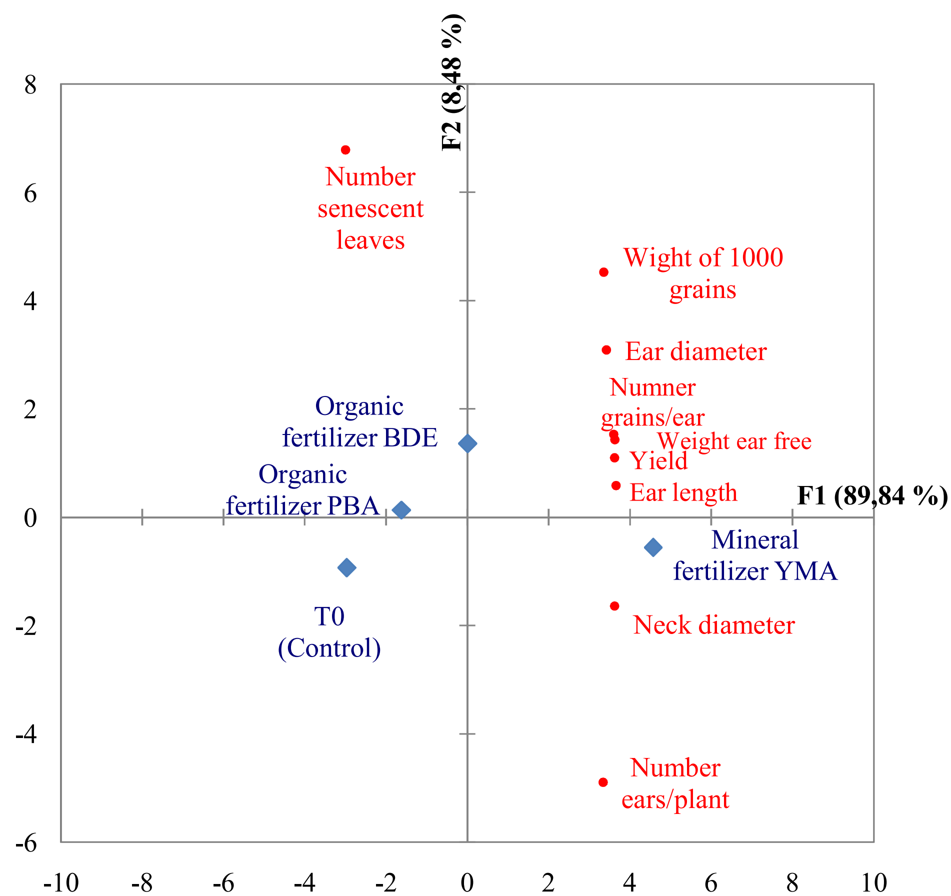

Fig. 1. Distribution of the treatements and the parameters studied in the Biplot plan

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 (Fig. 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 fertilisers (BDE and PBA) are located in the same quarter of plan, while the treatments with the mineral fertiliser and the witness each occupy a quarter of plan. The quarter of plan representing the control without fertiliser does not include any parameters studied. The organic fertilisers BDE and PBA belong to the same quarter of plan with the parameter number of senescent leaves. As for the mineral fertiliser, Fig. 1 shows, except the number of senescent leaves, a comparison between this treatment and all the other parameters studied.

3.2 Discussion

This study demonstrated the ability of mineral and organic fertilisers to enhance growth, fruiting and maize yield on the ferruginous soil. These results are similar to those obtained in other regions of sub-Saharan Africa, notably, on maize in Nigeria [10] and 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 fertilisation.

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 fertilisers. Depending on the initial soil composition of the study site, fertiliser 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 fertiliser brought between them shows that the mineral fertiliser 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 fertiliser is, consequently, observed on the general growth of the plants compared to the control and the organic fertilisers (BDE and PBA). These results show that there is a good response of maize plants to mineral fertilisation 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 fertiliser 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 fertiliser brought would have left in the soil so many mineral elements which allowed a favourable mineral nutrition and a good growth of the maize plants.

In general, the study on the comparison of the effects of fertilisers on aerial biomass production by maize plants shows that the control without fertiliser and organic fertilisers give the lowest yields. Soil poverty could be the main reason for these results. These results reflect the need for mineral fertilisation 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 the acceptable form [16]. Also, application of chemical fertilisers that provide nutrients such as nitrogen significantly increases maize biomass production [17]. Besides, the nutrients released by mineral fertilisers are directly and easily used by plants [16].

The low production of the control and organic fertilisers 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, insolubilisation of phosphorus which together contribute to the significant decrease in crop yields [18]. The slow release of mineral elements by organic fertilisers and the short corn crop cycle (about 90 days) would explain the identical production of above-ground biomass by organic fertilisers and control without fertiliser.

In our study, there was a significant improvement in production characteristics and maize grain yield, with a supply of mineral fertiliser and organic fertiliser compared to the control without fertiliser. These results show that maize has a good response to mineral and organic fertilisation 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 fertiliser (Yara) compared to organic fertilisers.

Chemical fertiliser input significantly increased corn yield compared to control plots and organic fertilisers.

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

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

The addition of mineral fertilisers significantly increases pollen production [20]. Which improved the rate of fertilisation of flowers. The mineral fertiliser, 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 fertilisers almost always improves yield [22]. Different studies have shown that nitrogen fertilisation accelerates plant growth and increases above-ground biomass and yield [23].

Mineral fertilisers provide high yields and good quality of grain corn and forage corn. However, these fertilisers can have negative impacts on the environment if their use is not optimised [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 fertiliser compared to control without fertiliser.

Organic fertiliser BDE and PBA had a much greater influence on maize plant production in the field, compared to the control without fertiliser, the improvement of all measured yield characteristics. This is explained by the number of mineral elements available to the plants. Organic fertilisers are an important source of mineral elements.

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

The control without fertiliser generally had much smaller effects on the improvement of all measured production parameters. This may be because 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 fertiliser 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 fertilisation for maize cultivation, through an improvement of production growth parameters, on the soils of the Korhogo region. Failing to apply the mineral fertiliser, for the cultivation of corn, organic fertilisers BDE and PBA could be used because of their effects on the yield.

4. CONCLUSION

At the end of this study, it appears that the mineral fertiliser (Yara) had the highest effects in improving the production of maize plants. Organic fertiliser 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 fertilisers in maize cultivation contributes to the understanding of the importance of organic fertilisation, which is a value to be sought to replace mineral fertilisers 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 fertiliser and organic fertilisers. It appears necessary to continue this study in all the agro-ecological zones of maize cultivation, and by varying the doses used, intending to an essential adjustment to popularised fertilisers, for a determination of economically profitable doses. These results will make it possible to optimise the use of organic and mineral fertilisers under maize cultivation in Côte d'Ivoire.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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