Effects of Two Different Types of Mineral and Organic Fertilizers on Morphological Characteristics and Yield of a Variety of Millet (*Pennisetum glaucum*), Cultivated in the Region of Korhogo

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ABSTRACT

Millet is a crop whose grains are produced in the diet of West African populations. The millet is still low in the said region. This study was initiated to help improve the productivity by evaluating the effects of different types of mineral and organic fertilizers on millet yield. The study was conducted in Korhogo region, located in northern Côte d'Ivoire, following a Fisher block device, comprising 7 treatments and 4 repetitions. The 7 treatments included two types of mineral fertilizers (Yara type and NPK type, with surface and poquet spreadings), three types of organic fertilizers (cow, rabbit and chicken droppings) and the control. The results showed that the production characteristics and yield were improved by NPK types and poultry dropout. These two types of fertilizer, with average yields, respectively, of 2.78 and 1.77 tons/ha, yielded the highest yields. Other organic fertilizers did not significantly improve millet production compared to the control. In this context where the high price of mineral fertilizers is very often a hindrance to the intensification of millet cultivation, this study constitutes a contribution to fertilization through the use of organic fertilizers and adapted to the socio-economic conditions of region, knowing the low incomes of peasants.

Keywords: *Millet, yield, mineral fertilizer, organic fertilizer, Côte d'Ivoire*

I. INTRODUCTION

The analysis of the situation and prospects for food security in sub-Saharan Africa shows a widening gap between consumption needs and food availability at the global level of countries, households and individuals. This situation leads to malnutrition and a marked undernourishment [1]. This state could worsen by 2050, following a very large increase in the population in the said region [2] [3]. Increasing the production of staple foods remains the only possibility of combating the increase in poverty and undernourishment.

In Côte d'Ivoire, agriculture is the basis of the economy, accounting for more than 40% of gross domestic product (GDP). However, cereal production, which should cover the needs of the population, is, in general, deficit, and population growth is not accompanied by that of agricultural productions, which keeps the country in food insecurity almost permanent, especially in the northern part of the country.

Millet (*Pennisetum glaucum*) is one of the most cultivated cereals in the world and the most important for the millions of people in the semi-arid and arid tropics of Africa, in particular, in northern Côte d'Ivoire [4]. Apart from human consumption, it is used in animal feed and in the agro-food industry (manufacture of alcoholic beverages, bread-making, biscuits, etc.). The low productivity of this culture, encountered in the Korhogo region, is mainly due to the sharp decline in soil fertility and rainfall.

In addition, increased climatic risks make it difficult to intensify the process of intensification based on the mobilization of financial capital [5] [6]. As a result, these production conditions, which are increasingly fragile and precarious, have a low income for rural populations [7]. Recent studies [8] [9] showed that low soil fertility would maintain populations in chronic poverty.

The decline in crop yields is also due to the low utilization of improved genotypes and agricultural inputs, the importance of damage caused by various pests and poor agricultural practices [10]. According to [11], inadequate management of plant nutrition contributes to lower soil fertility. Low soil productivity is therefore a major challenge for the achievement of food security and the socio-economic development of Côte d'Ivoire. Crop productivity can be increased, either by improving yields or by increasing the acreage of land developed for agriculture.

However, the soils of northern Côte d'Ivoire, in general, and those of the Korhogo region, in particular, belong to the category of ferralsols. These types of soils are characterized by an acidic pH [12], a low organic matter content [13], the presence of low-activity clays, mainly kaolinite and sesquioxides [14], as well as the unavailability of nutrients such as phosphorus and nitrogen, leached by wind or water erosion [15] [16]. Therefore, these soils are increasingly unproductive and, in extreme cases, agricultural activity would only be feasible with significant nutrient inputs [11].

To ensure a sustainable development of the country, it is necessary to improve soil fertility. Mineral fertilizers are known for their immediate and beneficial effects on yields. However, the majority of producers do not have access to them [17], given the high prices and inadequate technologies for the application of mineral fertilizers, with a consequent low rate of mineral fertilization [18] 19]. Many studies have looked at the importance of mineral fertilizer use [20] [21] [22] [11] [23]. The latter have the advantage of the availability, for the plant, of the minerals, the faster, favouring, thus, better production and high productivity [20]. However, their exclusive use leads to a decrease in organic matter, soil acidification, desaturation of the exchange complex, an increase in aluminum toxicity, so many factors that can reduce the yield.

In the face of this fact, [24] [25] suggested the use of organic manure. However, the release of the elements by the organic amendment is gradual and slow [26] [28]. Organic manure has very beneficial effects on the physico-chemical and biological properties of the soil and plays a very important role in mineral fertilization [29] [30].

Organic matter is an important source of nutrients for plants [31]. The use of organic fertilizers is, therefore, a key factor in the modernization of agriculture in developing countries.

The general objective of this study is to evaluate the behaviour of a traditional variety of millet with respect to two mineral fertilizers and three types of organic fertilizers. The objectives pursued by this research are the determination of the type of chemical and organic fertilizer most suitable for the cultivation of millet, allowing a better reaction of the variety of millet. Thus, the following assumptions were made

(i) the use of chemical and organic fertilizers improves the development and yield of millet, (ii) the variety of millet would act differently against the five types of fertilizer.

II. MATERIALS AND METHODS

A. Locality of study

The study was conducted in the municipality of Korhogo, located in northern Côte d'Ivoire, whose geographical coordinates are 9 ° 26 ' North longitude and 5 ° 38 ' West latitude. The climate of the Sudanese-type zone is characterized by alternating two seasons. A great dry season, from October to may, precedes the rainy season, marked by two rainfall peaks, one in June and the other in September. The area is also characterised by average temperatures ranging from 24 to 33 °c and a monthly average hygrometry of 20%. The annual rainfall is between 1100 and 1600 mm and the duration of insolation is 2600 hours per year.

The soil is of tropical ferruginous type, formed on granite with more or less intense leaching, reduced its fertility. The relief is generally flat and dotted with places of inselbergs ([32].

B. Plant material

The plant material used was made up of a traditional variety of millet (*Pennisetum glaucum* (L.) R.Br.). This variety is characterized by low yield, which is estimated to be about 0.5 tonnes per hectare, under the best cultivation conditions. The port of this variety is erected and the height of the plant seldom reaches 3 meters. The average length of the cycle is about 95 days. Seed have oval shape and yellow brown color. The shape of the spur is cylindrical, it is long 0.5-0.70 m. this variety is more cultivated in the Korhogo region.

C. Fertilizer products

Fertilization products were made up of three different types of organic fertilizers and two mineral fertilizers. This is:

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

-a mineral fertilizer, of type N-P-K, of formula 15-15-15 + 6S + 1B;

-an organic fertilizer, consisting of cow stock;

-an organic fertilizer consisting of chicken dropout;

-an organic fertilizer, consisting of rabbit dropout.

D. Experimental device, treatments and their application

The experimental device consisted of fully randomized Fischer blocks with 7 treatments and 4 repeats (blocks). The study consisted of 28 elementary plots. Each elemental parcel consists of 20 millet plants, planted on 4 lines of 5 poquets, according to the spacing of 0.80 m x 0.80 m. the elementary plots and blocks were separated from a distance of 1 m and 1 m, respectively.

The 7 treatments studied are as follows:

-T1: control without fertilizer intake;

-T2: organic fertilizer with cow stock;

-T3: organic fertilizer, with rabbit dropout;

-T4: organic fertilizer consisting of chicken dropout;

-T5: mineral fertilizer Yara Mila Actyva or YMA;

-T6: N-P-K type mineral fertilizer, by surface spreading on ridges;

-T7: N-P-K type mineral fertilizer, with application in micro-dose by poquet.

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

Poultry dropper (chicken) was delivered to the 400 g dose by poquet and per plant, or 8 kg per elemental parcel. Thus, 32 kg of chicken dropper were needed to cover the entire study plot.

The treatment, consisting of rabbit dropout, was applied at a dose of 400 g per poquet, or 8 kg per elemental plot.

The cow purse was applied at a dose of 400 g per poquet, a total of 8 kg per elemental parcel. Organic fertilizers were applied, at ploughing, before sowing, in crowns around each poquet.

The 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 20th day after sowing (DAS) and the second was carried out on the 37th DAS, at a dose of 30 g/plant.

The mineral fertilizer NPK, formulation 15-15-15 + 6S + 1B, was applied on the surface on the ridges on the one hand. The fertilizer was split and applied after sowing. The first application was made, with a dose of 30 g/plant, the 20th DAS and the second was carried out the 40th DAS, at the dose of 15 g/plant.

The mineral fertilizer NPK, formulation 15-15-15 + 6S + 1B, was, on the other hand, applied by micro dose to the poquet, in Crown around each plant, 5 cm from the plant and 2 cm deep. Two applications, at different doses, were performed 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.

E. Measured parameters

Various morphological and yield parameters were measured by elemental plot during the study.

The vegetative phase was determined by the duration between the dates of emergence and flowering. As for the reproductive phase, it was evaluated by the time separating the dates of flowering and maturity of the spikes. The height of each plant was assessed by measuring its size from the collar to the last newly opened leaf (arrow). The number of leaves emitted per plant was obtained by counting all the leaves formed. The number of tillers emitted per plant was obtained by counting all the tillers formed. The dry weight of each grains with the grains was determined by weighing each grain-bearing spike. The dry weight of each grain-free spike was obtained by weighing each spike after removal of all grains. The dry weight of the grains per spike was obtained by weighing all the grains removed on each spike. The yield (R/HA) was determined from the relationship below:

R = NE * PE * D, with
R: yield in tons/ha
NE: the total number of ears per hectare;
PE: weight of grains per ear in kg:
D: planting density with a standard is 15000 plant/ha

F. Data processing and analysis

The data, collected and saved using the Excel spreadsheet, has been subjected to a variance analysis using the XLSTAT software version 7.5. The level of significance of the differences between averages was estimated using the Duncan test at the 5% threshold for the classification of averages into homogeneous groups.

III. RESULTS

A. Effect of different types of fertilisers applied to morphological parameters

Table 1 shows the mean values of all growth characteristics obtained after the different types of organic and mineral fertilizers have been contributed. In terms of the duration of the vegetative phase of millet plants, the analysis of the variance does not reveal any difference between the averages obtained with all the treatments applied. These averages ranged from 100.7 days (T3) to 105.5 days (T1 and T7). The application of the different types of fertilizers did not affect the improvement of the vegetative phase of the plants.

As regards the duration of the reproductive phase of millet plants, the analysis of variance does not reveal any difference between the averages obtained with the different treatments used. These averages ranged from 42.5 days (T1 and T7) to 47.2 days (T3). The different treatments applied did not improve the duration of the reproductive phase of millet plants.

In the height of the millet plants, the analysis of the variance reveals no difference between the averages recorded with all the treatments applied. These averages ranged between 141.0 cm (T2) and 184.5 cm (T5). The application of the different types of fertilizers did not affect the improvement of the height of the plants.

In the analysis of this table 1, which presents the results of the average number of tillers formed by plant, differences were observed between the averages of the different treatments applied. The results obtained, with the different treatments, reveal the formation of four homogeneous groups. The first group is formed by the treatment T5 (mineral fertilizer Yara) whose effects in improving the number of tillers formed were the highest. This value was 10.2 talles. The second group consists of the averages obtained with the treatment T3 (9.4 tillers) and T7 (8.3 tillers). The fourth group consists of the averages of the T2 and T4 treatments, with respective values of 7.2 tillers and 7.5 tillers. The effects of these two treatments were the highest. These treatments have most improved the formation of the tillas by the millet plants.

As for the number of leaves emitted, presented in table 1, the variance analysis revealed differences between the averages obtained with the different treatments applied. The formation of the leaves is linked to the application of the different types of

mineral and organic fertilizers. The highest value was recorded with the T7 treatment, with an average of 75.3 sheets formed per millet plant. As for the low values, they were obtained with the T2 and T4 treatments, with respective averages of 47.7 sheets and 51.0 sheets.

Table (1): Mean values of the morphological parameters of millet according to the different fertilisers applied

Traitements	Vegetative phase (day)	Reproductive pase (day)	Plants height (cm)	Tillers number	Leaves number emited
T1 (control)	105.5 a	42.5 a	156.0 a	8.0 bc	59.9 bc
T2 (cow stock)	103.7 a	44.2 a	141.0 a	7.2 c	47.7 d
T3 (rabbit dropout)	100.7 a	47.2 a	175.2 a	9.4 ab	65.5 ab
T4 (chicken dropout)	103.2 a	44.7 a	182.9 a	7.5 c	51.0 d
T5 (mineral fertilizer Yara)	104.2 a	43.7 a	184.5 a	10.2 a	70.6 ab
T6 (NPK surface spreading**)**	104.2 a	43.7 a	143.7 a	8.2 bc	56.8 cd
T7 (NPK application by poquet**)**	105.5 a	42.5 a	176.5 a	8.3 ab	75.3 a

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

B. Effect of different types of fertilisers applied to production parameters

The average values of the production parameters, obtained after the different types of fertilizers have been contributed, are presented in table 2. In the analysis of this table, it appears that at the dry weight level of the grains per spike, the analysis of variance reveals differences between the averages obtained with the different treatments applied. The results show the formation of two homogeneous groups. The first group, having produced the highest effects, consists of the averages of the T4 (chicken Fiente) and T7 (NPK applied in poquet) treatments. The recorded values were 333.45 g and 212.90 g, respectively for T7 and T4. The second is the average of the T1, T2, T3, T4, T5 and T6 treatments. These averages were, on the whole, the weakest.

In terms of yield, the analysis of variance reveals differences between the averages obtained with the different types of fertilizers applied. It is clear fromthis analysis that two homogeneous groups have been established. The second group consists of the processing averages T1, T2, T3, T4, T5 and T6. These averages, varying between 0.85 t/ha and 1.77 t/ha, were the lowest. The first group is formed by the averages obtained with the T4 and T7 treatments. These two treatments produce the high averages. The values obtained were 2.78 t/ha for T7 and 1.77 t/ha for T4.

Table (2): Mean values of millet production parameters according to applied fertilizers

Traitements	Dry weight of the grains per spike (g)	Yield (t/ha)
T1 (control)	133.42 b	1.14 b
T2 (cow stock)	102.17 b	0.85 b
T3 (rabbit dropout)	164.40 b	1.37 b
T4 (chicken dropout)	212.90 ab	1.77 ab
T5 (mineral fertilizer Yara)	156.38 b	1.30 b
T6 (NPK surface spreading)	126.34 b	1.05 b
T7 (NPK application by poquet)	333.45 a	2.78 a

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

IV. DISCUSSION

This study demonstrated the ability of mineral and organic fertilizers to improve the growth, fruiting and yield of millet on a ferruginous soil. These results are similar to those obtained in other regions of sub-Saharan Africa, notably by [33] on maize in Nigeria and [34] on the same crop in Cameroon, showing that the general trend in the evolution of soil properties tested and yield was increasing with respect to control treatment, by mineral and Organic fertilization.

In the experiment, both vegetative and production parameters were improved, with the contribution of different types of fertilisers. It

therefore appears that the study site best valorizes fertilizers according to the initial chemical composition of the soil [35]. Mineral and organic manure had a significant influence on the growth and development of the vegetative plant of millet plants.

Comparison of the different types of fertilizers brought together shows that mineral fertilizers induced a higher growth in the number of tillers and leaves formed by plant which are excellent indicators of vegetative development. This evolutionary trend based on the type of fertilizer is, therefore, observed on the General growth of the plants compared to the control and the organic fertilizers. These results show that there is a good response of millet plants to mineral fertilization on the Ferruginous soils of Korhogo.

Indeed, these soils have a low potential for supplying mineral elements essential for the growth and development of millet. The mineral nutrition of the plants is thus inadequate. Mineral fertilizer intake fills this mineral deficiency and ensures proper plant nutrition.

Generally, the study of the comparison of fertilizer effects on aerial biomass production by millet plants showed that the control without fertilizer and organic fertilizers gave the lowest yields. Soil poverty could be the main reason. These results reflect the need for mineral fertilization to achieve good yields on these types of soils. Nutrients N, P, and K would play important roles in plant development and growth. The inadequacy or absence of these elements results in decreases in yields. Among the mineral elements, nitrogen would influence the growth of plants. Nitrogen is the main stimulant of plant growth [36] and all life forms cannot grow and function without acquiring nitrogen in acceptable forms [36]. In addition, the application of chemical fertilizers, with the exception of surface input, that provide nutrients such as nitrogen significantly increases the production of aerial biomass of millet [37]. In addition nutrients released by mineral fertilizers are directly and easily used by plants [36].

The low production of the control's air matter and organic fertilizers can be attributed to the characteristic factors of acidic soils: acidic pH, Al and mg toxicity, nutrient deficiencies (Ca, Mg, P, K, B) and a slow release of these mineral elements [38]. In addition, on plots, the absence of element inputs is accompanied by loss of organic matter and nutrients, soil acidification, reduction of biomass and microbial activity, insolubilization of phosphorus which together contribute to a significant decline in crop yields [39]. The slow release of mineral elements by organic fertilizers and the short crop cycle of millet (about 90 days) would explain the identical production of aboveground biomass by organic fertilizers and the control without fertilizer.

In our study, there was a significant improvement in production characteristics and yield of millet grains, with a supply of mineral fertilizer (NPK applied as a poquet) and organic fertilizer (chicken manure) compared to the control without fertilizer and other types of organic fertilizers. These results show that there is a good response of millet to mineral-based and Organic fertilization on the Ferruginous soils of the Korhogo region.

Chemical fertilizer intake significantly increased millet yield compared with control plots and organic fertilizers.

The desirability of the use of mineral fertilizers is revealed here, in that almost all agronomic parameters have increasing values with increasing the dose of fertilizer.

The beneficial effects of chemical fertilization, through agriculture, have been demonstrated by many authors [40] [41]. Mineral fertilizers have a greater agronomic efficiency because their elements are available and readily absorbed by crops compared to organic fertilizers. This gradual increase in the improvement of the parameters of production by the mineral fertilizer, is due in large part to its making available to the plants mineral elements that create the best conditions of mineral nutrition for the millet plants.

The increase in yields observed is due to the improvement of the nutritional status of the soil by the different intakes of fertilizer. [42] has shown that most soils with natural poverty react positively to different fertility improvement practices. This improvement has resulted in good plant nutrition, resulting in increased yields.

The doses of mineral fertilizer and chicken manure had a significant effect on millet grain yields. In general, mineral fertilizers produce a dramatic effect on millet yields. It is no longer useful to test the agronomic efficacy of mineral fertilizers used alone because many studies have shown their positive effect in the short term, but also their long-term negative effect on the chemical degradation of soils (decrease in pH and increase in exchangeable Al) thus resulting in a reduction in yield [43] [44].

The intake of chicken dropout doses also led to a significant increase in millet yields. Improved cereal yields through the application of chicken manure have been reported by several studies [45] [46] [47] [48]. It has been reported that a contribution of 5T/ha of chicken manure has doubled the yield of millet. It was pointed out that manure intake plays a very important role in nutrient recycling, soil fertility, and improved agricultural production.

By neutralising the low acidity of soils and bringing nutrients to plants, chicken manure improves mineral nutrition resulting in increased crop yields [49] [50]. These results confirm the easy mineralization of chicken manure and its richness in mineral elements for plant nutrition.

The study also showed that all production characteristics and yield were not significantly improved by other types of organic fertilizers brought in relation to the control without fertilizer. Organic fertilizers did not have a much sharper influence on the production of millet plants in the field compared to the control treatment without fertilizer, namely the improvement of all the performance characteristics measured. This is due to the slow mineralisation and the quantities of mineral elements made available to the plants. Indeed, organic fertilizers are an important source of mineral elements. Organic fertilizers are slowly mineralized. As the millet cycle is very short, organic fertilizers have not yet reached their mineralization phase, which would provide the mineral elements for the improvement of their productivity to millet plants.

The slow mineralization of organic fertilizers, the low grades of minerals made available to plants and the short production cycle of millet would explain the small improvement in the production of millet by the organic fertilisers brought by report to the witness without fertilizer.

A contrario, many studies have shown the beneficial effects of organic fertilizers on plant production. It has been shown that the application of organic fertilizers improves the physical, chemical and biological properties of the soil [51] [52]. The nutrients contained in organic fertilizers increase crop yields [53] [54] [55] reported that organic fertilizer applications composted as a source of nutrients had an impact on crop yield, indicating that the fertilizer value of these fertilizers was comparable to that of mineral fertilizers. [56] found that the yield of tomato was markedly increased by spreading septic sludge and that a difference was observed with other organic fertilizer treatments. In addition, the application of human faeces, as organic fertilizers, can recycle nutrients and eliminate the need to use chemical fertilizers in cultivated land [57]. The application of recycled organic fertilizers to agricultural soils improves the physical, chemical and biological properties of the soil, as they contain organic materials and plant nutrients [58].

The results obtained by [36] showed that the intake of organic manure leads to an increase in growth and improves crop yield. Indeed, many research studies have shown that the use of organic manure allows to obtain significant increases in yields on the plots of the beneficiary crops, thanks to the improvement of the fertility of the so1 [59].

Mineralization of organic matter by accelerating microbial biomass activity would be favoured by increased nitrogen content in organic fertilizers and soil pH [60]. The use of organic amendments lies in the fact that they play an important role on various soil properties [61]. In fact, local resources such as organic fertilizers and mineral fertilizers, applied to poor and acidic tropical soils provide the nutrients necessary for feeding and plant growth and therefore increases crop yield.

Control treatment without fertilizers generally had significantly low effects on the improvement of all measured production parameters. These effects are similar to those obtained with organic fertilizers. This could be due to the evidence that the soil of the witness would contain very few nutrients, necessary to improve the production characteristics and yield of millet plants. The low production of control soils can be attributed to the characteristic values of soils in the region, marked by their poverty in mineral elements. The absence of fertilizer inputs and the lack of mineral elements are accompanied by loss of organic matter and nutrients, soil acidification, biomass reduction and microbial activity [62].

The results, thus obtained, showed the importance of Organic fertilization (chicken fiente) and mineral (NPK applied in poquet) for the cultivation of millet, through an improvement of the parameters of growth and production, on the soils of the region of Korhogo. Failing to apply mineral fertilizer, for the cultivation of millet, organic fertilizers (chicken manure) could be used because of its efficiency on yield.

CONCLUSION

At the end of this study, it appears that mineral fertilizer (NPK, with poquet spreading) had the highest effects in improving the production of millet plants. Organic fertilizer intake, i.e., chicken droppings, has also improved all performance characteristics measured against the fertilizer-free control, cow and rabbit manure, and Yara mineral fertilizer.

The study on the comparison of the effects of mineral and organic fertilizers in millet cultivation contributes to the understanding of the importance of Organic fertilization, which is a value to be sought in replacement of mineral fertilizers whose high often been criticized by small producers.

Such a study becomes unavoidable in the conditions of particular culture of climate change, drastically influencing crop yields.

In the current context of poverty and continued degradation of land fertility, the adoption of less expensive regenerative fertility techniques is indispensable. Soil poverty in organic, phosphorus, potassium and nitrogen soils is the major constraint of agricultural production in Côte d'Ivoire, and particularly in the Korhogo region or the annual rainfall rarely exceeds 1200 mm of water.The results of this study which showed the improvement of production characteristics and yield by mineral fertilizer and organic fertilizers, recommend to continue it in all agroecological zones of millet cultivation, with a view to make the necessary adjustments to the popularized fertilizers, in order to avoid the inutilisation of mineral

fertilizers. For, the results have shown that it is possible to improve the productivity of millet, by the use of organic fertilizers, in particular, by the poultry manure.

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