Evaluation of Maize Varieties Performance to Different Doses of NPK Mineral Fertilizers in the Dry Savanna of Benin

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Abstract- Maize is a very demanding plant nutrient crop. However, since the promotion of this staple food crop in the 1960s, recommended doses of mineral fertilizers: 200kg/ha of NPK and 50kg/ha of Urea remained unchanged despite the very pronounced soil depletion in the dry savanna in Benin. The low level of soil fertility is therefore a major factor limiting maize production in northern Benin especially in certain localities in the dry savanna and despite the mineral fertilizers. The objective of this study is to find new optimal doses for more yielding of maize varieties recommended in these regions. The experiment was carried out at the Centre for Agricultural Research Ina (Ina-CRAN), three (03) maize short cycle varieties (90 days) were sown. Five doses of mineral fertilizers namely D1 = (200 kg NPK/ha⁻¹ and 50 kg urea ha⁻¹), D2 = (250kg NPK ha⁻¹and 62.5 kg urea ha⁻¹), D3 = (300kg NPK ha⁻¹ and 75kg of urea ha⁻¹) D4 = (350kg NPK ha⁻¹ and 87.5 kg urea ha⁻¹) and D5 = (400kg NPK ha⁻¹ and 100 kg urea ha⁻¹) were applied. The experimental design was a randomized complete block design with four replications. The results obtained showed that, dose D2 usually applied remains that which gives the highest yield estimated to 60q/ha. Varieties TZE Comp. 3DTCI and EVDT W 97 STR QPM are the most productive in the dry savanna. Maximum productivity (0.149 ± 0.02 kg / pl) was obtained with varieties TZE Comp. 3DTCI and EVDT W 97 STR QPM.

Key words: doses, dry savanna, maize, mineral fertilizers, varieties.

I. INTRODUCTION

Maize (Zea mays L.) is the second most important food crop after cassava on the African continent (4) and is a major staple food crop in sub-Saharan Africa (SSA). The average yield of maize in several African countries is 1 to 1.5 t ha⁻¹, only about a third of the world’s average [6]. Farmers of this region produce over 28 million tons of maize grain every year, accounting for 35% of the world’s maize production. The total maize production in Africa in 2007 was estimated at about 43.4 million tons [8].

In order to increase exports and reduce vulnerability of the economy from the external shocks, Benin government makes a choice of the economy diversification [14]. This diversification includes other crops as maize. Among the food crops, maize offers the highest yield per hectare. The national cereal crop production of Benin from 2008 to 2009 was 978.063 tons. Among this, maize production was estimated to 787.586 tons [7]. It is used directly for human and animal food and as raw material for many industrial products and represents a very important commodity in the international exchanges [11].

In Benin, maize has been subject to several studies including selection leading to the development of several high-yielding varieties. The large number of varieties allows production under varying climatic conditions ranging from sub-humid to semi-arid. However, the high number of varieties cannot compensate the dependence of varieties to climatic factors. However, the soil fertility decline is more pronounced in the dry savanna regions due to system of intensive agriculture, overland use without vegetation resulting in poor organic matter and strong sunshine due to climate change. Agbossou and Akponikpè highlighted by Bagan [2] stated that changes in the water balance does not compromise still dangerously looping cycle of maize, the most widely grown food crop in the country. But if the change continues, the national maize production will decrease. To cope with the adverse effects of high temperatures on soil fertility [13] recommends the revision of fertilization strategies. In Benin, maize has been subject to several studies including selection leading to the development of several high-yielding varieties. The large number of varieties allows production under varying climatic conditions ranging from sub-humid to semi-arid. However, the high number of varieties cannot compensate the dependence of varieties to climatic factors. However, the soil fertility decline is more pronounced in the dry savanna regions due to system of intensive agriculture, overland use without vegetation resulting in poor organic matter and strong sunshine due to climate change. Agbossou and Akponikpè highlighted by Bagan [2] stated that changes in the water balance does not compromise still dangerously looping cycle of maize, the most widely grown food crop in the country. But if the change continues, the national maize production will decrease. To cope with the adverse effects of high temperatures on soil fertility [13] recommends the revision of fertilization strategies. The combined effects of these depressed factors maintain agricultural soils in Benin including ferruginous
tropical soils in the northern Benin in a cycle of nutrient depletion. Thus, maize, the main cereal in the region, despite the mineral fertilizers does not express its full potential. Yields are below expectations and doses of mineral fertilizers recommended in maize (200kg NPK ha⁻¹, 50kg urea ha⁻¹) did not take into account implications of climate change.

Therefore, it is essential to know whether the doses of mineral fertilizers recommended in the dry savanna could be used as optimal due to climate variability. The objective of this study was to evaluate the performance of maize varieties to different doses of NPK mineral fertilizers in order to determine the optimal dose and more yielding varieties in these regions.

II. MATERIAL AND METHODS

A. Experimental site

The study was conducted on the experimental site Angaradebou (10° 90'-11° 35'N and 2° 38'-3° 15'W) located in the district of Kandi. This site belongs to the Agricultural Research Centre-North (INA Ina-CRAN). It is subjected to an atmosphere of Sudanese type with alternating rainy season (May to October) and a dry season (November to April) marked by the harmattan. The average annual rainfall varies between 800 and 1300 mm. It was 1019.20 mm in 2007. [4] Soil base granite-gneiss is the most common and suitable for all food crops in northern Benin.

B. Plant material

The plant material used consists of three drought tolerant short-cycle varieties (90 days). Seeds are provided by the Centre for Agricultural Research CRAN-Ina. Names and the average weight of 1000 grains at 14% moisture content of each variety are listed in Table 1.

C. Experimental design

The experiment was arranged in a randomized complete block design with four replicates and two factors with specific levels giving 15 treatments and a total of 60 experimental units. The first factor is three varieties of maize with short cycle (90 days): Variety 1 TZE Comp.3DTC, Variety 2: Bag Comp.3x4 TZE; Variety 3: EVDT W 97 STR QPM. The second factor is 5 mineral fertilizers doses: D1 = 200 kg ha⁻¹ NPK and 50 kg ha⁻¹ Urea; D2 = 250kg ha⁻¹ NPK and 62.5 kg ha⁻¹ Urea; D3 = 300kg ha⁻¹ NPK and 75kg ha⁻¹ Urea; D4 = 350kg ha⁻¹ NPK and 87.5 kg ha⁻¹ Urea; D5 = 400kg ha⁻¹ NPK and 100kg ha⁻¹ Urea.

D. Sample area

On each elementary plot, there are 4 lines of seedlings spaced 0.80 m apart and 13 planting holes of 0.40 m per line. The sampling area was made on all plots. Lines and border plants are excluded and observations are made on the two central lines of seedlings. Two lines on four were harvested, giving a harvested area of 8 m². The ears were harvested counted and then weighed. The moisture content of the grain was measured.

E. Data collected

- The percentage of emergence (P) is the ratio of number of shoots removed (n) number of planting holes (N) per treatment) multiplied by 100. P = 100 n / N
- The date of 50% male flowering: This date is taken as soon as it was noted that half of the plants present in the plot are the male flowers.
- Height of plants: the average plant height as the height of insertion of the lowest spike is obtained by measuring the great rule (2m long) on a sample 20 plants per treatment previously labeled.
- Circumference of neck stems: it is taken with the caliper (10th place)
- Number of plants harvested from the two center lines
- Weight of harvested ears: it is the weight of ears per plant harvested on all elementary plots obtained by counting.

F. Statistical analysis

ANOVA was performed using the software SPSS 16.0 and STATITCF on the variables and their interaction to 5% xxxx if the returns are statistically different or not depending on the treatments.

III. RESULTS AND DISCUSSION

A. Overview on rainfall

The study of rainfall during the trial period (May-October 2009) is lower (617.3 mm) than the level of rainfall required for maize production in the region (1100-1200mm) (CRAN-Ina, 2009). The high rainfall period was in August with 181.5 mm rainfall [8] which justifies the choice of short cycle varieties (90 days). Figure 1 shows the distribution of monthly rainfalls and the number of rainy days during the growing season. The rainfall in August (181.5 mm) was greater than the average (102.88 mm). However, it is clear from this figure that maize plants received sufficient water at the beginning of vegetation 133.5 mm compared to the average (102.88 mm).
B. Productivity and yield of maize varieties

Soils of dry savanna are characterized by a lower organic matter, cationic exchange capacity and poverty characteristic. Thus, mineral fertilizers NPK when applied to these soils, nutrients are leached therefore unavailable for use by crop. [10] The application of both organic manure and chemical fertilizer can not only reduce the amount of fertilizer minerals needed by the culture but also to increase their use [16]. Analysis of the average productivity of short cycle varieties showed that the variety 1 (TZE Comp.3DTC1) shows the maximum productivity (0.149 ± 0.02 kg / plant) to dose 1 and productivity minimum (0.132 ± 0.04 kg / plant) to dose 3. The other three fertilizer doses induced productivities all lower than that recorded at the dose 1. Variety 2 (Bag Comp.3x4 TZE), is more productive to dose 3 (0.141 ± 0.02 kg / plant) and less productive at dose 5 (0.116 kg / plant). When considering the variety 3 (EVDT W 97 STR QPM), the maximum value (0.149 ± 0.01 kg / plant) was observed at dose 1 and the minimum value (0.130 ± 0.02 kg ha⁻¹) in dose 4. It is clear from this analysis that dose 1 is one which confers high productivity varieties with the exception of variety 2 where high productivity is achieved with dose 3. Therefore, we can conclude that the recommended dose applied to the short cycle varieties usually in the dry savanna allows the variety 1 and the variety 3 to express their productivity.

**Figure 1:** Evolution of the monthly rainfall during the trial period in Angaradebou

<table>
<thead>
<tr>
<th>Variety</th>
<th>Doses of mineral fertilizers</th>
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<tbody>
<tr>
<td>TZE Comp.3DTC1</td>
<td>D1</td>
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<td></td>
<td>0.149 ± 0.02</td>
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<td></td>
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The grain yield of short cycle varieties depending on the doses of mineral fertilizers (Table 2) showed that variety 1 (TZE Comp.3DTC1) has the highest yield (61.92 ± 8.73 q / ha) at dose 5 and the lowest yield (48.31 ± 14.71) at dose 3. Variety 2 (Bag TZE Comp.3x4) with dose 1 showed the highest yield of 57.64 ± 8.22 q / ha while the lowest yield (46.52 ± 7.71) was obtained with dose 5. The yields obtained with the other three doses were low compared to that obtained with dose 1. Variety 3 (EVDT W 97 STR QPM), also has the highest yield (63.42 ± 7.65 q / ha) with dose 1. The lowest yield (50.55 ± 6.36 q / ha) was obtained with dose 3. The yields obtained with the other three doses are below those with dose 1. However, the results of the analysis of variance showed that there was no significant difference between the yields of the varieties at the same doses and the interaction between varieties and doses. However, comparing average yields between the different doses applied showed a statistically significant difference (p = 0.011) between doses 1 and 3. The lack of significance of the interaction between variety and dose leads us to compare for the varieties studied all doses.

Table 2: Short cycle varieties grain yields to different doses of mineral fertilizers (q/ha).

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Maize yields obtained in this study were higher than average yield (34 - 43q/ha) recorded in Africa since 1990. [3] These low yields despite increased doses of fertilizer applied (200kg/ha to 400kg/ha) of N16 P16 K16 confirms the need for poor soils of dry savanna organic manure to increase the uptake of mineral fertilizers by plants. Indeed, several studies in West Africa [1] showed that the incorporation of corn crop residues have increased significantly yields. However, in most African countries, crop residues are often removed from fields for other uses [13]

IV. Conclusion and Suggestions
The different doses of mineral fertilizers applied did not significantly affect the performance and productivity of maize varieties. The effects of climate change on soil nutrients are not even noticeable to the point of recommending new doses of mineral fertilizers. This represents a decrease of increased fertility due to overland use of the soil. Indeed, the usual dose (200 kg ha-1 NPK + 50 kg ha-1) gave high yields with the varieties studied. Also recommending new doses would be more accurate if we had a priori analyzed soil of this locality.

References