Effects of Fertilization Based on Chicken Manures and Mycorrhiza on Vegetative Parameters and Phenological Stages of *Sorghum bicolor* in Yagoua, Far-North Cameroon

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Authors' contributions

This work was carried out in collaboration among all authors. Authors BWB designed the study. Author DDD performed the statistical analysis. Authors BWB and JDH wrote the protocol and wrote the first draft of the manuscript. Authors PSA, BWB and PK managed the analyses of the study. Author BWB and PSA managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Study aims to evaluate the effect of chicken manure and mycorrhiza levels as fertilizers on vegetative growth and on phenological stages of Sorghum in Far North Cameroon.

Place and Duration of Study: The study was conducted in the Valorization Station of Agricultural Research (PSAR) of Yagoua.

Methodology: For this study, variety S-35 of Sorghum have used. Three levels of fertilization were used to evaluate germination rates, vegetative growth and phenology of this variety. The levels of fertilizers applied were 20 g of mycorrhiza, 50 g of organic manure and 20+50g of effect combined mycorrhiza+organic manure in comparison to the check (0g). The experimental design was the randomized block design with 3 replications. After evaluation of germination rates in the farm, we had evaluated the height, diameters and precocity of plants.

Results: Uses of different levels of fertilization on germination rates were important for all the levels of fertilizers compared to the control (27. 5 %). It's varying from 52.5 % for the chicken manure, followed by the effect of combined treatments (45 %) and bio-fertilizers with 67 %. Compared to the check, the use of chicken manure as fertilization was most significant ($P<0.05$) on the height of plants during the vegetative growth. The diameters of plants according to the different treatments were most significant ($P<0.05$) respectively by the supplies of chicken manure, the effect of both treatments (mycorrhiza+chicken manure) and mycorrhiza treatment. Theses different levels fertilization was influenced the phenological stages of plants especially first flowering of plants days after sowing. Flowering of plants at 50 % was most favorable for the treatments based on the uses chicken manure and the combined effect of treatments (mycorrhiza+chicken manure).

Conclusion: Uses of chicken manure and mycorrhiza as fertilizers on Sorghum were significant to the vegetative growth and flowering stages of plants. Levels of chicken manure had positive effect on plant height. Plants diameters were most positively affected by organic manure, mycorrhiza and the effect of both treatments during growing of plants.

Keywords: Sorghum, Mycorrhiza, Fertilizers, Phenological stages, Chicken manure, Far North Cameroon.

1. INTRODUCTION

Sorghum (*Sorghum bicolor* (L.)) is an annual plant of the Family Poaceae, sub-family of Panicoïdeae, gender of Sorghum (Dogget, 1988). In recent years affected by climate change

sorghum become one of major crops for food security. Comparatively to maize, Sorghum reputed to be less for water requirement. However, low temperature and water stress disturb Sorghum than maize (Moreau, 2007). In the world Sorghum is consider as a fifth plants among cereals (FAOSTAT, 2008). In sub-saharian Africa this plants appear as a second cereals according to the cover surfaces and productivity after Maize and Rice (FAOSTAT, 2015). In sahelian zone, it is the first crop after millet. The two crops cover together 50 to 70 % of cultivated surfaces (Comas Jordi, 2001).

North and Far North region of Cameroon belong to Sudano-sahelian zone characterized by the irregular period of raining seasons, dryness which all are correlated to the climate change (Donfack *et al.,* 1997). The main causes are due to the anthropic factors such as intensive deforestation of savannah and steppe for the expansion of culture and income of woods resources of populations (Donfack *et al.,* 1997). These two regions cover a surface of 100.354 km^2 and count near of 5 billions of inhabitant, about 25, 6 % of populations of country (INS, 2008). These populations are made up of 65% of rural people who eat mainly legumes and cereals including Sorghum. The annual product change from 680 000 ton against 380 000 ton for Maize and less of 150 000 ton for Peanut (INS, 2008). Seeds can be consumed in whole or shell for doing gruel, couscous (Chantereau *et al.,* 2013; Kayodé, 2006). They are also used in the production of alcohol, traditional beer in Africa (Chantereau *et al.,* 2013). Flaw is an important sub-product of sorghum that can be used like a food for animals, combustible or a material for building. All the plant can be used. According to the useful of this plant, we distinguish fodder sorghum, grain sorghum and ensilage (Rapport CMA/OC, 2004).

Despite her economic in the northern part of Cameroon, this crop meets most environmental disturbance related to irregular rainfall, poverty of soil, migratory birds and climate changes which destabilizes and make worse the expansion of this cereals (Comas Jordi, 2001). However, needs of foods consumption of Sorghum by local supply cause problems. Several methods are used to increase crops yield of plants by the uses of pesticides, chemical fertilizers, genetically modified organisms (new varieties) (Dalgaard *et al.,* 2003). These methods are considered as dangerous for the health of consumer and the environments (Bowers *et al.,* 2001).

However, few researches on fertilization of Sorghum were realized in Cameroon especially in the Far north region. In theses cases, it is judicious to improve the abilities of plants to take themselves nutrients elements on theirs environments for growing and good quality of product for consumer. Mycorrhizas are beneficial associations among soils fungi and plants roots. They appear as an alternative to improve soils availability on nutrients elements for plants growth without impacting the environment and humans. In this context the present study proposes to evaluate the effect of combination of types of fertilizers (chicken manures + mycorrhiza) on vegetative parameters of the S-35 Sorghum variety in the rural area. This study aims to evaluate the responses S-35 Sorghum variety to the types of bio-fertilizers (chicken manures + mycorrhiza) on growth plants parameters and productivity in rural area.

I- MATERIALS AND METHODS

I.1. DESCRIPTION OF STUDY

The study was conducted in Yagoua locality, precisely in Valorization Station of Agricultural Research (PSAR) of Yagoua. This locality is located in the Department of Mayo-Danay, Far-North region of Camreoon with the geographical coordinates at 10°19'45.4" North and 15° 15'35.7" East. Altitude of the area is 255 m.

I.2 Agroecological description

Mayo-Danay belongs to Sudano-sahelian climate type which is characterized by two seasons: a raining season from June to October with a maximum pluviometry from August-September and a dry season for the remaining months. The average amount of rainfall recorded in recent year ranges from 600 to 800 mm of rain per year with the average temperature of 27, 5° C. Relief of this area is characterized by a savannah landscape on a uniform plain. The area is characterized by a dry atmosphere threatened through a dry wind and dusty which came from the North (Harmattan) and another moist which came from the south (Mousson) during all year.

Vegetation was cover with an arboreous savannah and grassy steppe. It is composed of thorny shrub and grass. The anthropic factors due to human's activities also influence the zone. Arboreous layer (2 à 4 m) is sparsed, very sahelian appearance to *Acacia seyal*, *Butyrospermum parkii*, *Faiderbia albida*, *Anogeissus leocarpus*, *Balanites aegyptiaca*, *Tamarindus indica*. Herbaceous layer was dominated mostly by perennials and annual plants of the family of graminaceae that mostly are *Andropogon spp*, *Loutedia togoensis*, *Schoenefel diagracilis*. Agroforestry town of the locality of Yagoua are composed by some plants of Neem (*Azadirachta indica*) and *Senna sp*. We encounter also *Tamarindus indica*, *Borassus aethiopum, Adansonia digitata*, *Ficus spp* and *Moringa oleifera* within the zone. The incomes of the inhabitants come essentially from some annual crops such as Millet (*Pennisetum glaucum*), Sorghum (*Sorghum bicolor*), Maize (*Zea mays*), Peanut (*Arachis hypogea*), Fonio (*Digitaria sp*), Cowpea (*Vigna unguiculata*) and vegetable crops as Carrot (*Daucus carota*), Watermelon (*Citrullus lanatus*), Tomato (*Lycopersicum esculentum*), Onion (*Allium cepa*), Gombo (*Albelmoschus esculentus*), Lettuce (*Lactuca sativa*), Black nightshade (*Solanum scabrum*).

II. VEGETAL MATERIALS

For this purpose, the variety of Sorghum used is S-35 which provides from Institute of Agricultural Research for Development (IRAD). This variety had a late cycle of development which varying from 90 to 160 days.

II.2 BIOLOGICAL MATERIAL

II.2.1 MYCORRHIZA

Bio-fertilizer Myco coming from GIC AGRIBIO CAM is used like biological. It is adapted to local sols for nursery (legumes, fruit and horticultural plants) and field like leguminous, cereals and fruits. This bio-fertilizer is characterized by 4 types of AMC such as, *Rhizophagus irregularis* (50 %), *Scuttellospora gregaria* (10 %), *Gigaspora margarita* (20 %), *Glomus hoi* (20 %).

Picture 1: Mycorrhiza containing 4 types of CMA (source, WANG-BARA Bertrand, 2018).

II.2.2 CHICKEN MANURES CHARACTERISTICS

The physico-chemical characteristics of organic manure are showed in the table 1 below.

Table 1: Physico-chemical characteristic of chicken manures.

Caractéristiques	Valeurs
pH-eau	7,6
pH-KCL	7,3
CO (%)	13,80
M.O (%)	23,70
N (%)	3,01
$N\text{-}N0_3$- (mg/kg)	48,16
$N\text{-}NH_4^-$ (mg/kg)	36,96
C/N	4,58
Ca^{2+}	115,20
Mg^{2+}	275,60
K^+	69,49
Na^+	27,83
Exchangeable bases	488,12
Total Phosphorous	6878,3
Humidity (%)	21

Sources: Tatieze (2016).

Organic manures (chicken manures) applied on the soil had moderately alkaline pH. This chicken manure could enhance the pH of this soil as more favorable for the availability of nutrients elements of plants. The level of organic matter is very high and good according to the

quality (C/N≤10). Nitrogen content is very high and the total Phosphorus within organic manure is also high.

III. METHODS

III.1 EXPERIMENTAL DESIGN

The study have been realized on a surface of 181, 65 m^2. Experimental design for this study is a Randomized Complete Block Design (RCBD) with 3 replications. The factor is represented by the bio-fertilizers and chicken manure treatments with 4 levels (T0= control, T1= mycorrhiza, T2 = chicken manure and T3= chicken manure + mycorrhiza) with a total of 12 treatments within 3 blocks. Experimental unit are constituted of 2, 5 m × 3, 2 m = 8 m^2. Each block is divided in sub-blocks and they are equal according to a distance of 1m. Experience started by manual clearing of weeds. A labor of 25 cm of depth was made in order to mix the soil and remove some grass and arboreous. Sowing has been made two weeks after labor. The distance within space line is 80 cm and 25 cm from poquets. The total densities of plants per unit are 40, such as 10 per lines and 4 lines for each unit. The seeds were sown on soil at the depth of 3 to 5 cm. Weeding has been made every two weeks during the period of culture.

III.2 INOCULANTS AND ORGANIC MANURE

The quantities of each treatment was measured with an electronic balance (2000*0,1g). The doses are defined as follow: 20 g for the treatment of mycorrhiza (T1; T3), 50 g for the treatments of chicken manure (T2; T3). The inoculation process used is a method described by GIC AGRO-BIOCAM, which consist to coat each seed before to receive mycorrhiza treatments during one hour. Seeds were mixed at 20 g of mycorrhiza with water then sow after. Organic manure treatments (T2; T3) was been applied 2 weeks after sow at the quantities of 50 g per poquet. Levels of treatments were fixed as follow: T0 = control; T1 = 20 g of mycorrhiza; T2 = 50 g of chicken manure; T3 = 20 g of mycorrhiza + 50 g of chicken manure.

III. 4 ASSESSMENT OF PARAMETERS

III.4.1 GERMINATION PARAMETERS

Data collection was done from 5^{th} to 10^{th} days after sowing (DAS). They consist for each unit per treatment to count the number of germinated plants and those which dit not germinated in order to evaluate the germination rate of different treatments according to following formula:

III.4.2 GROWTH PARAMETERS

Data of growth were collected. They consist to collect data in 4 replications in a time interval of

10 days during phenological growth stages plants at 30th, 40th, 50th and 60th DAS. Five plants on a central line for each treatment was been taken like a reference for collecting data of growth parameter such as height of plants with meter, diameter of noose with caliper.

III.4.3 VARIETAL PRECOCITY

Precocity parameters were evaluated on five plants in the central line take as a reference for collecting data of each treatment. The effects of different levels of treatments (fertilizers) were observed on the day of 1st flowering plants and 50 % of flowering plants.

III.5 STATISTICAL ANALYSIS

Data collected for each parameter were recorded on a table of Excel de Microsoft. 2017. These data were transferred from the software of R-commander for analysis of variance (ANOVA) and the means were been separated with the test of Kruskal for the comparison of average at 5 % of probability.

IV. RESULTS AND DISCUSSIONS

IV.1 GERMINATION RATES

Data of germination rate taken 10th days after sowing on a density of 40 plants per sub-unit were evaluated according to the **Figure 1** below. These data permit to evaluate the effect of different treatments (mycorrhiza, chicken manures and associations of mycorrhiza + chicken manure on the field. According to this graph, we can observe the difference between germination rates of plants for each treatments used. Germination rates changes according to the treatment applied. The results obtained showed a significant difference among different treatments ($P \leq 0.05$) compared to check. Germination rates are high for the treatments of organic manures (chicken manures) with 52. 5 %, association of mycorrhiza + chicken manures with 45 %, following by the treatment of mycorrhiza with 41.67 % compared to control (27.5 %).

NB: Histograms with the same letter are not significantly different at the level of probability considered ($P \leq 0.05$). **T0=** control; **T1=** mycorrhiza; **T2=** chicken manures; **T3=** mycorrhiza + chicken manure.

Figure 1: Effects of different types of fertilization on the germination rates.

IV.2 GROWTH PARAMETERS

IV.2.1 EFFECT OF TREATMENTS ON HEIGHT OF PLANTS

The plant height for different levels of fertilizers to flowering stages of plants during growing are presented in **Table 2**. Results of this table show that the height increased with all the levels of fertilization until flowering stages of plants. Plants height variations taken every 10 days from 30th to 60th days after sowing were most significant for the treatments of chicken manures for all the DAS during the growth of plants. Followed by the treatments of mycorrhiza + chicken

manure from 50th to 60th DAS. Statistically, significant difference (P ≤ 0.05) was recorded by the applied of chicken manure within the treatments compared to control according to the days after sowing from 30th to 60th DAS. The height average at theses days according to the kruskal test varies respectively from 0.92 m to 2.09 m.

Table 2: Effect of different types of fertilization on Sorghum plants height.

Treatments	Height of plants (m)			
	30th DAS	40th DAS	50th DAS	60th DAS
T0	0.86 ± 0.09b	1.08 ± 0.28b	1.25 ± 0.22b	1.62 ± 0.27b
T1	0.86 ± 0.10b	1.05 ± 0.08b	1.20 ± 0.13b	1.62 ± 0.16b
T2	0.92 ± 0.04a	1.31 ± 0.11a	1.70 ± 0.11a	2.09 ± 0.14a
T3	0.83 ± 0.17b	1.06 ± 0.20b	1.27 ± 0.38b	1.69 ± 0.59b

NB: Values of the column for a variable followed by the same letter are not significantly different at the level of probability considered (P ≤ 0.05). **T0=** control; **T1=** mycorrhiza; **T2=** organic manures; **T3=** mycorrhiza + chicken manure.

IV.2.2 EFFECT OF TREATMENT ON THE DIAMETER OF PLANTS

Plant diameters by treatments during growing stages of plants are presented on **Table 3**. The diameters of plants increased with the different levels of fertilization. The diameters of plants collected during growing periods from 30th to 60th DAS was most significant (P ≤ 0.05) for all the different treatments compared to control. The average plant diameter according to the kruskal test at this time ranges from 14.79 mm to 20.24 mm in terms of chicken manure used. This is followed by the combined effect of treatment with the diameters varying from 11.84 mm to 17.60 mm and mycorrhiza treatments from 11.05 mm to 14.47 mm. Statistically, a significant difference (P ≤ 0.05) was recorded by the uses of chicken manure, the combined effect of mycorrhiza + chicken manure and mycorrhiza treatment compared to control according to days after sowing at 30th, 40th, 50th and 60th DAS.

Tableau 3: Effect of different types of fertilization on the diameter of plants.

Treatments	Diameters of plants (mm)			
	30th DAS	40th DAS	50th DAS	60th DAS
T0	8.81 ± 3.43c	10.49 ± 3.59c	12.57± 3.55c	16.35 ± 2.79b
T1	11.05 ± 3.30b	12.74 ± 3.38b	14.47 ± 3.45b	16.67 ± 3.80b
T2	14.79 ± 1.93a	17.12 ± 1.89a	19.02 ± 1.80a	20.24 ± 2.01a
T3	11.84 ± 3.64ab	14.23 ± 3.60ab	16.11 ± 4.02ab	17.60 ± 3.94ab

NB: Values of the column for a variable followed by the same letter are not significantly different at the level of probability considered (P ≤ 0.05). **T0=** control; **T1=** mycorrhiza; **T2=**

chicken manures; **T3=** mycorrhiza + chicken manure.

IV.3 PHENOLOGICAL STAGES OF PLANTS

IV.3.1 EFFECT OF TREATMENTS ON FIRST FLOWERING OF PLANTS

Figure 2 shows the first flowering day after sowing of plants according to the different levels of fertilizers used. We recorded that the different treatments influences first flowering DAS during the growth of plants. First flowering appeared earlier after applied chicken manures (T2) at 64th DAS, followed by the treatments of mycorrhiza (T1) at 65th DAS and the effect of combined of two treatments (T3) at 67th DAS comparatively to the check (T0) at 68th DAS. The effects of three treatments positively induces first flowering (days) of this variety because we observe earlier flowering stages of plants for different treatments compared to the check.

NB: T0= control; **T1=** mycorrhiza; **T2=** chicken manures; **T3=** mycorrhiza + chicken manure.

Figure 2: Effect of different types of fertilization on the 1st flowering of plants.

IV.3.2 EFFECT OF TREATMENTS ON 50 % FLOWERING OF PLANTS.

Figure 3 shows the effect of different types of fertilization on flowering of plants at 50 % day after sowing. We recorded that the treatments of chicken manures (T2) and effect of combined treatments (T3) were positively induces flowering stages of plants at 50 %. Flowering at 50 % appeared earlier at 71th DAS after applied chicken manures (T2), followed by the effect of combined of two treatments (T3) at 72th DAS and mycorrhiza treatments at 73th DAS compared to the check (31th DAS).

NB: T0= control; **T1=** mycorrhiza; **T2=** chicken manures; **T3=** mycorrhiza + chicken manure.

Figure 3: Effect of different types of fertilization on flowering of plants at 50 %.

DISCUSSIONS

Objective of this study was to evaluate the effect of different types of fertilizers (mycorrhiza, chicken manure and mycorrhiza+chicken manure) on growing parameters and phenological stages of the variety S-35 of Sorghum in rural area. However, the germination rate of plants for each treatment was determined. Germination rate of plants varies according to different levels of fertilization applied. Results showed that the inoculation alone at 20g, the chicken manures supply at 50g and the combined effect enhances the height of plants during vegetative stages. Works of Abdourahmane et al. (2020) proved the positive effect of chicken manure on the germination rate of plants of Millet (Poaceae) from 2nd to 5th DAS. This improve of germination rate come from the good depth of sowing process, spacing of poquets. Fertilization effects based on chicken manure can improve the vigour of plants during germination compared to the

check (Abdourahmane *et al.,* 2020).

Results showed that the inoculation alone at 20g, chicken manures supply at 50g and the combined effect improves the height of plants during vegetative. Referred to the check, plants height variations taken from 30th to 60th DAS were most significant for the treatments of chicken manures for each DAS during the growth of plants. Followed by the treatments of mycorrhiza + chicken manure from 50th to 60th DAS and mycorrhiza only at 60th DAS. Ours works corroborate with the works of Tshibingu et al. (2017) showing a good growing on the height of plants of Maize on the plots which receives fertilization (organic or mineral) compared to the check. Contrasly, works of Plenchette et al. (2000) proved that the mycorhization of Millet by *Glomus aggregatum* did not stimulate its growth. But works of Laminou (2010), shows that the inoculation with mycorrhiza stimulate the growth of Sorghum (*Sorghum bicolor* (L.)) and Cowpea (*Vigna unguiculata* (L.)). By the process of decomposition and mineralization, nutrient elements provides to different types of fertilization such as Phosphorous, Nitrogen which are available for the growth of plants (Amadou *et al.,* 2019; Sylvia *et al.,* 2005). In the context of soils poverty in rural zone, the uses of organic matter could facilitate the penetration of plant-roots, circulation of air or water in the soil and the formation and maintenance of Argilo-humic complexe of soil (Amadji and Migan, 2001; Amidou *et al.,* 2005).

Results on the diameters of plants showed that the inoculation alone, chicken manures applied and both two treatments contributes to increasing plants diameters according to the repetitions (days). However, the variations of plants diameters depend on the levels of fertilization used. Compared to the check, the diameters of plants collected during growing periods from 30th to 60th DAS were most significant for all the different treatments compared to check. Similarly works of Tshibingu et al. (2017) proves that the diameters of plants are higher on fertilized plots of Maize compared to the check. According to the works of Aristil (2019), a diameter of plants of Sorghum related to the fertilization varies according to the types of fertilizers applied. The supplies of organic matter on soil permit to stimulate the activities and the diversity of soil micro-organisms (Carpenter-Boggs *et al.,* 2000). In return this microbial community by degrading the organic matter will liberate the mineral elements available for plants and favorite their developments.

The results of phenological stages of plants showed that the uses of different levels of fertilization earlier induces first flowering of plants for all treatments at 64th DAS (chicken manure), 65th DAS (mycorrhiza) and 67th DAS (effect of combined of treatments). Concerning the flowering at 50 % and referring to the check, we recorded that chicken manures and effect of combined treatments were positively induces flowering of plants. Flowering of plants were earlier for theses treatments respectively at 71th DAS and 72th DAS during growing. According to works of Abdourahmane et al. (2020) phosphorous provides in organic manures stimulate flowering, precocity of flowering and harvest. Flowering was earlier on the plots which were received fertilizers through nutrients contents in mould amendments. In contrast, results of Kabrah et al. (1996) shows that excess of Nitrogen in the soil causes late or absence of

flowering due to excessive elongation of vegetative period.

CONCLUSION

The objective of this works was to evaluate the different types of fertilization on vegetative parameters the variety of Sorghum S-35 on a rural zone. From the results obtained, the uses of certain types of fertilization were significant to vegetative parameters and flowering stages of plants according to the days. The supplies of levels of chicken manure were positive to the height of plants. Diameters of plants were most favorable by the uses of organic manure, mycorrhiza and the effect of both treatments during growing of plants. Theses treatments induces earlier the first flowering stages of plants and 50 % of flowering of plants was most favor by the treatments of chicken manure and the combined effect of mycorrhiza + chicken which appear earlier compared to the check.

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