



Effect of a Water Retainer on the Productivity of Millet (*Pennisetum typhoides* (L) R.Br.) at the Farako-Bâ Research Station in Western Burkina Faso

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Abstract

The degradation of soil fertility and the poor spatial and temporal distribution of rainfall are constraints on the improvement of Burkinabe agriculture. In order to find solutions to these constraints, the trial set up in rainfed conditions in Farako-Bâ in western Burkina Faso aimed at contributing to the improvement of millet yields by using a synthetic fertilizing water retainer, Polyter. The experimental set-up was in completely randomized Fisher blocks, comprising seven treatments and four repetitions. The only factor studied is the polyter. For the chemical parameters of the soil, the measurements concerned the pH-water; organic carbon; total nitrogen; the C/N ratio; assimilable phosphorus; and available potassium. As for the agronomic parameters, the measurements focused on the height of the plants; the diameter of the collar; the number of leaves; humidity levels; the weight of 1000 grains; grain and straw yields. The results showed that the application of Polyter, combined with organo-mineral fertilization, improved the agro-morphological parameters of millet. The moisture content measurement showed that the average moisture content of the Polyter treatments was better than those without Polyter. The best millet yields are the result of treatments with Polyter and organo-mineral fertilization for grain yields of 1993 kg/ha and 5772 kg/ha in straw. Polyter combined with organo-mineral fertilizers thus improves the productivity of millet. It is interesting to continue the study in other pedoclimatic zones in order to propose adapted formulas to better contribute to the improvement of millet productivity.

Keywords: Polyter; Moisture content; Organo-mineral fertilization; Productivity; Burkina Faso

Introduction

In Burkina Faso, cereal crops occupy more than 88% of the 3.7 million hectares of land sown each year [1]. Cereals are generally produced in a continuous monoculture system without restoration of soil fertility [2]. Of these crops, millet (*Pennisetum typhoides* (L.) R. Br.), is one of the main crops that ranks third in cereal production [3]. Millet cultivation is an absolute necessity because it represents a unique component of biodiversity in the agricultural and food security systems of millions of poor farmers in sub-Saharan Africa [4]. Millet occupies an important place in agricultural production. In addition to being an important source of food for the population, biomass is an excellent fodder for livestock feed. However, its productivity remains low due to abiotic constraints with low soil fertility and poor control of millet cropping systems. The average yields in a farmer environment of 795 kg/ha bear witness to this compared to potential yields of 1500 kg/ha [5].

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Very often, poor soil is reserved for millet farms in certain areas, on the pretext that it is less demanding in terms of soil fertility compared to other crops such as maize. Millet cultivation in Burkina Faso is based on a low use of quality seeds, infertile soils with diseases that negatively impact yields. To overcome the difficulties mentioned, it is necessary to explore other methods and techniques in order to improve crop productivity in a context of spatio-temporal irregularity of rainfall and a continuous decline in soil fertility. For example, Polyter made of cellulose, cross-linked acrylamide and potassium acrylate copolymers, organic fertilizers and growth promoters are alternatives. In view of the importance of millet in Burkina Faso, many works have been carried out to help improve its productivity. It is with this in mind that this study has been initiated. This study aims to contribute to the improvement of millet productivity through the use of a fertilizing hydro-retainer that is Polyter.

Methodology

Presentation of the study site

The study was conducted at INERA in the Farako-Bâ station located 10 km southwest of Bobo-Dioulasso on the national road n°7 linking Bobo-Dioulasso to Banfora. Its geographical coordinates are 4°20' west longitude, 11°06' north latitude and is located at an altitude of 405m. The climate of the study area is South Sudanese with a rainy season from May to October and a dry season from November to April [6]. The average rainfall was 1031.7 mm of water from January to September 2022 on 55 rainy days (weather at Farako-Bâ station during year 2022). The vegetation is dominated by a wooded savannah with *Vittelaria paradoxa*, *Faidherbia albida*, *Combretum micranthum*, *Parkia biglobosa*, *Anogeissus leiocarpus*, *Lannea microcarpa*, *Khaya senegalensis*, *Bombax costatum*. According to Da et al. [7], the soils of Farako-Bâ are tropical ferruginous soils.

Material

The plant material used is millet seed with the variety Missari 1 which has a cycle of 90 days and a potential yield of 2 t/ha. For the mineral fertilizers NPK 14-23-14, Urea 46% and Polyter as well as the organic fertilizers, compost was used.

Méthods

Experimental device

The trial is a completely randomized Fisher block device with seven four-repetition treatments, for a total of 28 elementary plots and the only factor studied is Polyter. The dimensions of each elementary plot are 5m × 5m, i.e. 25m² made up of 06 vegetated lines, including three lines for the useful plot. An interval of 2 m separates the blocks and 1 m between the elementary plots. The total surface area of the system is 840m². The different treatments are presented in Table 1.

Table 1: Compared treatments.

Treatments	Designations
T0	Control
T1	NPK treatment (200kg/ha) + Urea (150kg/ha)
T2	Organic manure treatment (10 t/ha)
T3	Polyter 3g Treatment/Pocket
T4	Organic manure treatment (10 t/ha) + NPK (200kg/ha) + Urea (150kg/ha)
T5	Polyter treatment 2g/pocket+ NPK (200kg/ha) + Urea (150kg/ha)
T6	Polyter treatment 2g/pocket + organic manure (10 t/ha) + NPK (200kg/ha) + Urea (150kg/ha)

Conduct of the test

The trial was conducted in 2022-2023. For the T2, T4 and T6 treatments, the dose of organic manure incorporated to the soil before sowing was 10 t/ha, i.e. 25 kg of organic manure per elementary plot. As the T1, T4, T5 and T6 treatments contain mineral fertilization, NPK with formulation 14-23-14 is applied at a dose of 200 kg/ha, i.e. 0.60 kg per treatment on the 15th DAS (Day After Sowing). As for urea (46% N), it was applied at a rate of 150 kg/ha, i.e. 0.45 kg per treatment. For the T3, T5 and T6 treatments (Polyter treatment), the Polyter in dry granules is placed in pockets 10 to 15 cm deep. It is covered up to 3 cm deep before the seed is placed. The doses of Polyter used were 2g/pocket for the T5 and T6 treatments, i.e. 62.5 kg/ha, and 3g/pocket for the T3 treatment, i.e. 93.75 kg/ha. Manual weeding was done as needed.

Data collection

Before the trial was set up and after millet was harvested, soil samples were taken at a depth of 0 - 20 cm for chemical analyses. These samples were taken with an auger following the diagonal of the useful plot at three points to constitute a composite sample. Soil analyses were carried out at the Soil-Water-Plant laboratory of INERA Farako-Bâ and the chemical parameters of the samples were determined. The chemical analyses concerned the water pH, organic carbon, total nitrogen, available potassium, and assimilable phosphorus. The pH (water) is measured by the electrometric method with a glass electrode pH meter [8]. The organic carbon content was determined according to the method of [9]. The method of Walinga et al. [10] was used to determine nitrogen. The available phosphorus was extracted using the Bray [11] method. Potassium was extracted from the soil with a solution of 0.1N HCl and 4N oxalic acid (H₂C₂O₄).

Yield parameters

Straw yield and grain yield were determined from the collection of data in the area of each elementary plot. The weight of 1000 grains, the grain yield and the straw yield of millet were evaluated.

Analyses of the data collected

The data collected was entered with the Excel 2016 spreadsheet and analyzed with the software GENSTAT, Edition 12, Version 2009. The treatment averages were compared by the student-Newman-Keuls test at the 5% significance level, to check for significant differences between the means. The histograms and graphs were made using the Excel 2016 spreadsheet.

Results

Results of soil analyses

Table 2 shows the chemical composition of the soil. There is no difference between the soil of the plot before cultivation and that of the plots cultivated in terms of pH, nitrogen content, organic carbon and the C/N ratio, regardless of the treatment. On the other hand, there are significant differences between the plot before cultivation and the plots under cultivation, for the values of assimilable P and available K, regardless of the treatment. The assimilable P content of the soil in the T4

(organic manure (10 t/ha) + NPK (200 kg/ha) + Urea (150 kg/ha)) and T2 (organic manure (10 t/ha)) treatments increased by 52% and that of the soil taken in the T6 treatment (Polyter 2g/pocket + organic manure (10 t/ha) + NPK (200 kg/ha) + Urea (150 kg/ha)) increased by 45% compared to that from the T0 control treatment. The level of potassium available in the soils from the plots under cultivation is higher than that of the soil taken before cultivation. The increase in the level of potassium available in the soil compared to the level of available potassium observed in the control soil (T0) is 17% for the soil in the T2 treatment, and 16% for the soil in the T6 treatment.

Effect of Polyter on millet yield parameters

Table 3 shows the weight of 1000 grains, the grain and straw yields of millet. The weight of 1000 grains did not vary regardless of the treatment. There was no significant difference between the weight of 1000 kernels of millet from fertilized treatments and millet from millet cultivation in the control plot. On the other hand, there was a significant

Table 2: Chemical characteristics of soil and after polyter use.

Treatments	pH	Carbon (%)	Nitrogen (%)	C/N	Phosphorus (mg.kg ⁻¹)	Potassium (mg.kg ⁻¹)
Before cultivation	5.01±0.4	0.33±0.07	0.030±0.00	10.98±0.86	3.38±2.44	50.39±8.86
T0	5.17±0.23	0.31±0.08	0.028±0.00	10.09±0.33	1.35c±0.40	42.77c±4.70
T1	5.31±0.55	0.34±0.03	0.030±0.01	11.40±0.62	2.18b±0.31	50.15b±2.35
T2	5.30±0.20	0.32±0.03	0.029±0.00	10.79±0.62	4.22a±1.60	60.25a±5.37
T3	5.24±0.20	0.31±0.03	0.030±0.00	11.02±0.36	2.84b±0.82	51.22b±5.10
T4	5.03±0.44	0.34±0.06	0.026±0.00	10.22±0.64	4.27a±0.69	53.52b±6.36
T5	5.14±0.11	0.36±0.07	0.030±0.01	10.81±0.62	1.50c±1.54	52.78b±8.54
T6	5.23±0.15	0.34±0.03	0.033±0.00	10.09±0.80	3.60b±0.62	58.84b±5.62
Probability	0.764	0.911	0.767	0.187	0.0001	0.0001
Signification	NS	NS	NS	NS	HS	HS

NB: T0 = Absolute control without any application, T1 = NPK treatment (200 kg /ha) + Urea (150 kg/ha), T2 = Organic manure treatment, T3 = Polyter treatment 3g/pocket, T4 = Organic manure treatment (10 t/ha) + NPK (200kg /ha) + Urea (150kg/ha), T5 = Polyter treatment 2g/pocket + NPK (200kg /ha) + Urea (150kg/ha), T6= Polyter treatment 2g/pocket + organic manure (10 t/ha) + NPK (200kg /ha)+Urea (150kg/ha), HS = Highly Significant; NS = Not significant. The values affected by the same letter(s) in the same column, are not statistically different at the 5% significance level according to the Student-Newman-Keuls test. PH: Hydrogen potential; C: organic carbon; N: total nitrogen; Pass: assimilable phosphorus; Kdispo: potassium available.

Table 3: Weight of 1000 grains, grain yields and millet straw.

Treatments	Weight 1000grains (g)	Grain yield (kg/ha)	Biomass yield (kg /ha)
T0	8.5±1.29	772 ^a ±50	2152 ^a ±58
T1	9.1±0.94	1138 ^a ±42	3414 ^b ±26
T2	9.3±1.33	888 ^b ±58	2607 ^a ±23
T3	8.8±1.21	1056 ^c ±63	3035 ^b ±30
T4	9.6±1.30	1409 ^e ±75	4019 ^c ±25
T5	9.8±0.96	1595 ^f ±39	4483 ^c ±52
T6	9.5±1.50	1993 ^g ±32	5772 ^d ±61
Probability	0.996	<0.0001	<0.0001
Signification	NS	HS	HS

variation ($P < 0.0001$) between treatments in grain and millet straw yields. The yield of millet grains from the T6 treatment increased by 1221 kg.ha⁻¹, i.e. 48% compared to that of millet from the control plot. The millet grain yield increased by 823 kg.ha⁻¹ or 35% in the T5 treatment. Indeed, the yield increased by 637 kg.ha⁻¹ or 29% for millet in the T4 treatment. On the other hand, the lowest yield of millet grain comes from the T0 treatment. Millet straw yields from the T6 treatment remained higher than those obtained from the T0 control treatment. Millet straw yields increased by 3620 kg.ha⁻¹ or 46% and by 2331 kg.ha⁻¹ or 37% respectively in the T6 and T5 treatments. On the other hand, the lowest yield of millet straw also comes from the T0 treatment.

Discussion

Soil chemistry

Regardless of the treatment, the site's soil is acidic before and after cultivation. This could be related to the nature of the soil. Our results are in agreement with those obtained by Diessana [12] who showed that the soils of our study site are acidic. The low level of organic matter recorded in the soil of our study site could be due to the nature of the soils in tropical environments. The work of Koulibaly et al. [13] maintains that the cultivation of land with or without fertilization leads to a rapid decrease in the stock of organic matter. Regardless of the type of treatment and fertilizers applied, the organic carbon and nitrogen levels do not vary significantly between treatments. These results could be explained by the decrease in soil microbial biomass. In addition, this could be explained by a low accumulation of leaf biomass in the plot. The low nitrogen level could be explained by the decrease in the accumulation of organic matter, but also by tillage which leads to a loss of nitrogen through mineralization and water erosion [14]. In addition, it can be justified by the fact that the plant uses mineral elements, especially nitrogen, for its growth but also by the leaching of mineral elements. The C/N ratios of the soil are similar regardless of the treatment. This would be related to the levels of organic carbon in the soil. C/N ratios that range from 10 to 11 indicate an average rate of mineralization of organic matter that could indicate a decrease in soil carbon levels. The assimilable p content observed in the soil of the T4 and T2 treatments varies significantly with higher levels. This clearly shows the positive effect of organic manure on improving the availability of phosphorus in the soil. The lowest assimilable p content comes from the Control treatment. The decrease in the assimilable p content reflects the proliferation of arbuscular mycorrhizal fungal spores in the soil.

The levels of assimilable p in the whole are low and below the deficiency threshold set at 10mg/kg of soil for this type of soil [15]. The available K contents of the T2 and T6 treatments vary significantly between treatments. These results could be explained by the contribution of organic manure to the soil.

Sui et al. [16] concluded that the incorporation of organic matter into the soil could enrich the environment with nutrients. The observation was made by Koulibaly et al. [17], who had found that fertilizer inputs improve the available K content. The differences in variations observed between these levels of assimilable P and available K are due to the beneficial effect of compost. According to Sikuzani et al. [18], compost inputs have a significant effect on the P and K content in the soil. The doses of water-retaining fertilisers applied did not have a significant influence on the level of organic matter (OM), nitrogen (N), available phosphorus and available potassium.

Yield parameters

The weight of 1000 grains of millet is similar for all treatments. This shows that the polyter and the organo-mineral fertilisers did not have any influence on the weight of the grains. The same observation was made by Diouf [19] on millet. The best yields of grains and straw come from the T6 treatment (Polyter 2g/pocket + organo-mineral fertilization). This means that the elements contained in the Polyter and those from organo-mineral fertilization would have stimulated the productivity of the millet. The grain and straw yields obtained in this treatment could probably be explained by good rooting of millet plants with the loosening of the soil by Polyter. This would result in a good water and mineral supply of millet plants. In addition, its importance in nitrogen dynamics would have an influence on plant nutrition. The same observation was made by Lompo [20]. These results are consistent with those obtained by Ambouta and Moussa [21] who showed that 10 kg/ha of Polyter allows a 27% increase in yield on millet compared to the cropping system <manure + mineral fertilizers. Polyter also improves the soil's water-holding capacity. This factor improves dry matter production, which results in plants with good vigour and better resistance to climatic hazards, resulting in better yields of both grain and straw. The production of above-ground biomass could be explained by the doses of soil nutrient content from Polyter that would have contributed to the growth and vegetative development of millet plants. Also, this could be explained by the availability of nutrients. Indeed, according to Traore et al. [22], the development of above-ground biomass in a crop is all the more important when the soil itself is rich in fertilizing elements. These results are in agreement with the work of Konfe et al. [23] who concluded that the effect of Polyter combined with organo-mineral fertilization on tomato and eggplant significantly improves above-ground biomass compared to treatments without Polyter.

Conclusion

This study was carried out with the aim at contributing to the improvement of millet productivity. The study showed that Polyter did not have a significant influence on soil chemistry. However, we note that polyter promotes good

soil water retention, better plant growth and also improved grain and biomass yields of the crop. Thus, the evaluation of the soil moisture content showed significant differences between Polyter and non-Polyter treatments. In fact, Polyter treatments have the best moisture levels compared to those of treatments without Polyter. Polyter therefore promotes the water nutrition of plants even under water-stressed conditions. It creates an environment conducive to water retention that will be made available to plants as and when needed. In addition, the water retainer in combination with organo-mineral fertilizers induced a considerable increase in agromorphological parameters. Analysis of the results revealed a positive response of millet to the combined effect of Polyter and organo-mineral fertilization. Thus, it can be said that the grain and straw yield of millet improves when Polyter is combined with millet production. In perspective, we suggest the continuation of this study in other pedoclimatic zones of the country in order to propose appropriate recommendations to better contribute to improving millet productivity.

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