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Effect of organic amendments based on date palm residues on barley crop (*Hordeum vulgare* L.) in an oasis environment: case of the Oued Righ region, Algeria.

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Abstract. The Saharan soils are known to be poor in organic matter and mineral elements essential to plants. In this context, the field trial has been conducted in the experimental station of the National Institute of Agronomic Research of Algeria (INRAA) of Sidi Mehdi Touggourt in order to improve soil agronomic suitability of the region's palm groves and increase yields. The trial examined the effect of five treatments, including an unamended control and four combinations of organic amendments and/or chemical fertilizer (compost, biochar + compost, biochar + fertilizer and fertilizer alone) on some growth and yield parameters of the barley crop (number of tillers per plant, plant height, and grain yield). A randomized experimental design with three repetitions was used. For all studied parameters, the biochar + fertilizer treatment ranked first compared to the other treatments. In terms of grain yields, it exceeded 51 qt/ha followed by fertilizer treatment (49.9 qt/ha). The compost amendment gave a yield of 36.6 qt/ha. The biochar + compost treatment and the control (cultivated without amendment) were the last with yields of 30.8qt/ha and 27.7 qt/ha, respectively. The statistical study revealed significant to very highly significant differences between treatments depending on the parameters.

Key words: *Hordeum vulgare* L.; date palm residues; biochar; compost; Oued Righ; Algeria.

1. Introduction

Agricultural practice in the Saharan regions is subject to various obstacles which the farmers make considerable efforts to manage and maintain the proper functioning of their farms. The low soil organic matter content in these regions [1, 2, 3] is particularly worrying because of its direct impact on agricultural production. The low level of natural fertility in relation to soil and climatic particularities of the Saharan regions according to Oustani (2006) [2], means that organic amendments are essential to improve the soil agronomic abilities of these regions. To overcome



this obstacle, oasis farmers buy important quantities of manure from cattle, goat, sheep and poultry origin at high prices. Palm groves, on the other hand, produce significant amounts of residue that are poorly valorized and are most frequently burnt. Blanchard et al. (2014) [4], suggest ways to improve such a situation by increasing organic manure quantity through the mobilization of unused biomass and improving the quality of organic fertilizers by better control of production processes. In this context, production and agronomic valorization of compost and biochar produced from date palm residues adhere to this approach. The present study is part of this framework and aims to highlight the effect of compost and biochar amendments made from date palm residues on the productivity of barley crops.

2. Materials and methods

2.1 Study site

The study was carried out in the experimental station of the National Institute of Agronomic Research of Algeria in Sidi Mehdi, Touggourt. The station is located in the Oued Righ region, whose climate is Saharan with strong aridity due to the lack of precipitation and the very high potential evapotranspiration (Beggar, 2006) [5]. The soils are sandy and aerated on the surface, mostly salty or very salty (Abid, 2018) [6]. Soil analysis carried out at the CAMA laboratory (Reims, France) showed that the organic carbon content was slightly low (6.4 g C/kg soil), with an alkaline pH, of around 7.9. The total nitrogen and phosphorus contents were low, recording levels of 0.52 g/kg, 27 mg/kg respectively. The potassium content was 264 mg/kg.

2.2 Plant material

The plant species chosen for this study was barley (*Hordeum vulgare* L.) and the Algerian variety used was "Saida". According to ITGC (2006) [7], this variety is known for its resistance to cold, and drought. It is sensitive to shedding. It is semi-early and has white ears and a very loose compactness of ear.

2.3 Experimental protocol

The methodology used to investigate the impact of amendments on the growth and yield of barley crop was a randomized design with three replications. The use of five different modalities is shown in table 1. Row sowing was conducted on plots of 2.4 m² at a dose of 160 kg/ha. The trial was carried out during 2022 – 2023 season. The plots were irrigated by flooding. Manual weeding was performed when necessary.

Table 1. Applied Treatments

Treatments	Symbols
Control: cultivated without amendment	T0
Compost	Cp
Biochar enriched with compost	Br Cp
Biochar enriched with fertilizer	Br Fz
Chemical fertilizers	Fz

2.4 Organic amendments and fertilizers: dose and method of application

Compost and chemical fertilizers were applied directly to the experimental plots. On the other hand, biochar was enriched with nutrients before incorporation into the soil. This step is essential

because some biochar's fertilizing capacity is considered negligible (Chabani et al. 2015) [8]; and according to Kasozi (2010) [9] the high adsorption capacity of most biochars limits nutrients availability to. The method conducted by Ndoung et al. (2021) [10] was adopted, it was a post-pyrolysis enrichment method that involves contact with compost or mineral fertilizers. According to biochar water retention capacity, the water amount used for fertilizer solution was 3 l of water for 1 kg of biochar. The contact duration was 10 days with fertilizer solution and 15 days with compost.

Application doses

Chemical fertilizers:

- Phosphorus was provided as a single application of mono-ammonium phosphate (MAP) (12-52-0), at a dose of 15.3 g/m²
- Nitrogen was applied in three times. At the emergence stage in the form of urea (46 % of N) at a dose of 4.7 g/m², the second dose took place at the tillage stage with urea at a dose of 8.7 g/m² and the last addition at the rising stage with nitrogen sulfate at 19 g/m².
- Potassium was provided as a single application of Potassium sulfate (0-0-51) at a dose of 20.1 g/m².

Compost: it was made from palm residues and cattle manure in Palm Compost company (Biskra, Algeria). The dose applied is 2.7 kg/m².

Biochar: the biochar used was produced by pyrolysis of date palm leaves. After crushing and sieving, it has been enriched with the chemical fertilizers (NPK) and compost at the same doses as used for the other treatments. The dose applied was 10 tons of biochar per hectare or 1 kg/m².

Amendment technique consists to deposit fertilizers, compost and enriched biochar as close as possible to plants. A furrow of 5 cm deep was made at 5 cm near plants and then amended. All amendments were applied at crop stage of 2 to 3 leaves.

2.5 Studied plant parameters

The evaluation of growth parameters was carried out on a sample of 10 plants per plot, taken randomly. However, the grain yields correspond to the harvest of each trial plot. Studied parameters were number of tillers per plant, plant height and grain yield.

2.6 Statistical study

The results were analyzed using the XLSTAT program. The method used was variance analysis (ANOVA). The Fisher test was used for classify means and distinguish between homogeneous groups at $\alpha = 0.05$.

3. Results and discussion

3.1 Number of tillers

The Cp amendment had an average number of tillers very close to the control (table 2). On the other hand, Br Fz treatment had the highest average, followed by Fz treatment.

Statistical analysis revealed a highly significant difference in number of tillers between the treatments with chemical fertilizers and others. BrFz and Fz formed a single group. According to Bourriche and Guenez (2020) [11], the number of tillers per plant is considered a component

explaining dry matter yield. Massele (1981) and Meynard (1980) *in* Bourriche and Guenez (2020) [11] note that this parameter is influenced by temperature, nutrient uptake level, varietal characteristics and cultivation techniques. In this study, barley was grown under the same soil, climatic and agricultural conditions, therefore the differences in the number of tillers per plant were linked to the different types of applied amendments.

Table 2. Means comparison of studied plant parameters according to applied amendments

Treatments	number of tillers per plant	Plant height (cm)	Grain yield (qt/ha)
Br Fz	4.6 ± 0.9 a	62.8 ± 6.6 a	51.3 ± 7.2 a
Fz	4.1 ± 0.06 a	56.5 ± 4.1 a	49.9 ± 9.1 a
Cp	2.3 ± 0.3 b	46.3 ± 7.6 b	36.6 ± 12.7 ab
Br Cp	2.5 ± 0.5 b	36.8 ± 3.1 bc	30.8 ± 5.8 b
T0	2.3 ± 0.9 b	36.2 ± 3.8 c	27.7 ± 12.6 b
Coefficient of variation	0.3	0.2	0.3
Pr > F	0.004	0	0.047
Signification	**	***	*

T0: Control, Cp: Amendment with compost, Br Cp: Amendment with biochar enriched with compost, Br Fz : Amendment with biochar enriched with fertilizer, Fz : Mineral amendment with chemical fertilizers.

Means assigned the same letter in the same column are not significantly different at 5 % level by Fischer test.

* Significant: p-value <0.05, ** highly significant: p-value <0.01, *** Very highly significant: p-value <0.001.

3.2 Plant height

The treatments presented a very high significant difference and BrFz dominated other amendments with an average height of 62.8 ± 6.6 cm and a maximum value reaching 81 cm. The mean comparison test revealed four homogeneous groups (table 2).

Hamdi (2022) [12] conducted a study on the barley crop (Saida variety) under the influence of manure and compost, revealing values that are lower than those found in this study. They varied from 42 cm to 51 cm. Diallo *et al.* (2008) [13] consider plant height growth as an indicator of soil fertility. On the other hand Jeffery *et al.* (2011) [14] note that biochar acts on plant growth by increasing nutrients availability and through its effect on water retention capacity which is greater in amended soils compared to unamended soils.

3.3 Grain yield

The Br Fz treatment exceeded 51 quintals per ha (qt/ha), followed by fertilizer treatment (49.9 ± 9.1 qt/ha). Compost amendment gave 36.6 ± 12.7 qt /ha. The Br Cp treatment and the control come last with yields of 30.8 ± 5.8 qt /ha and 27.7 ± 12.6 qt /ha respectively (Figure 1). ANOVA showed a significant difference between amendments and distinguished three homogeneous groups (table 2). Br Fz and Fz treatments were in agreement with a yield target of 50 qt/ha predetermined when calculating appropriate amendment doses.

Kelala (2022) [15] obtained higher yield with compost amendment than manure and fertilizers (NPK). Annabi *et al.* (2007) [16] concluded that organo-mineral fertilization effect on crop development was better than that of chemical fertilization. In the presence of a limited

number of works on the effects of biochar in arid regions according to Kavvadias *et al.* (2024) [17], the results obtained in this study are promising.

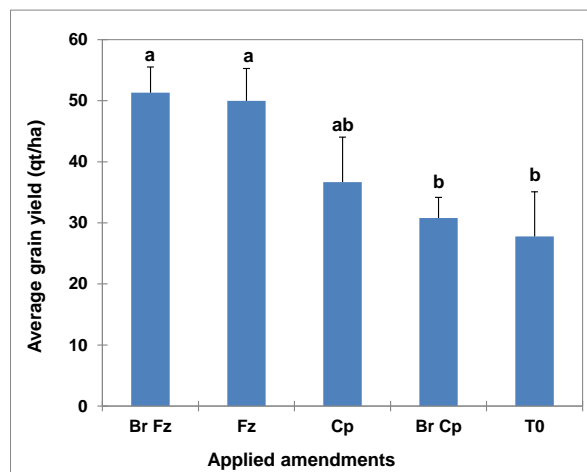


Figure 1. Average grain yield and standard errors according to applied amendments (n=3)

T0: Control, Cp: Amendment with compost, Br Cp: Amendment with biochar enriched with compost, Br Fz : Amendment with biochar enriched with fertilizer, Fz : Mineral amendment with chemical fertilizers. The litters indicate whether the differences between treatments were significant at the 5% level.

4. Conclusions

Evaluation of growth parameters and grain yield in the presence of organic amendments (compost and biochar derived from local date palm residues) compared to mineral fertilization revealed that biochar enriched by fertilizers in comparison with unamended control enhance barley crop production for about 24 qt/ha. However, the comparison of grain yield values between the couples Br Fz and Fz, Br Cp and Cp showed the absence of a significant effect after biochar application.

The study revealed significant to very highly significant differences between treatments with chemical fertilizers and organic amendments.

The analysis of data pertaining to the impact of applied amendments on soil qualities will provide a clearer explanation of the obtained results and enable the guidance of research work in accordance with the soil and climatic conditions of oasis regions.

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