Project Number: 1567

Project Acronym: ISFERALDA

Project title: Improving Soil FERtility in Arid and semi-arid regions using Local organic DAte palm residues

D5.5-5.6 Report on the presentation and analysis of the results of the field experiments at the plot scale and at the field scale

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Field studies were conducted over three crop seasons (2021-2022, 2022-2023 and 2023-2024), including the local barley varieties Saida in Algeria and Ardhaoui in Tunisia. A common protocol was established and shared between all partners, with the objective that it be applied at the five experimental sites: the INRAA station of Touggourt, the ITDAS station of Hassi Ben Abdallah, Ouargla, and the UMKB agronomic station in Biskra in Algeria and the IRA station of El Fjé Médenine and El Atilet oasis of Kebili in Tunisia.

The trials included a comparison of unamended control plots and chemically fertilized plots with plots amended with organic products that were locally available (e.g. unprocessed manure) or developed as part of the ISFERALDA project (compost and biochar). All fertilizing compounds were applied at a dose estimated based on the nitrogen requirements (grain and straw) for a 50 qt/ha grain yield objective. For compost, a hypothesized compost mineralization rate of 20% over the crop season (and no nitrogen loss) was used for the calculations.

In the **INRAA station of Touggourt**, Algeria, trials included compost, chemical fertilizer and manure in 2021-2022 (Figure 1). Biochar produced by ISFERALDA partners UMKB-UB was added in 2022-2023 and was enriched before field application by two-week contact with either compost or chemical fertilizers. In 2023-2024, the plots of 2022-2023 were sown again but the application of fertilizers was not renewed, in order to test their effect after the year of application. Only additional plots, not cultivated in 2022-2023, received chemical fertilizers to test the inter-annual variability.

Part of the corresponding results are discussed in a paper published in the proceedings of the International Conference on the Impacts of Soil Amendments in Dryland Agro-Ecosystems (ISADAE) that was organized by URCA in October 2024 (see WP6):

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

A. Tirichine, A. Abid, L. Hafouda, M. Sbih, M. Gommeaux, B. Boumaraf, M. Moussa, B. Marin, E. Le Guyader, V. Kavvadias, X. Morvan. *In press*

Figure 1: Sowing at the INRAA station of Touggourt for the 2023-2024 field trials.

In the year of application (2021-2022 or 2022-2023), the biochar + fertilizer treatment allowed the best plant development and grain yield, slightly (but not statistically significantly) improving over fertilizer alone (Figure 2), both being very close to the yield objective. Compost or manure amendment showed a slight but unsignificant improvement in plant development and grain yield over the unfertilized control.

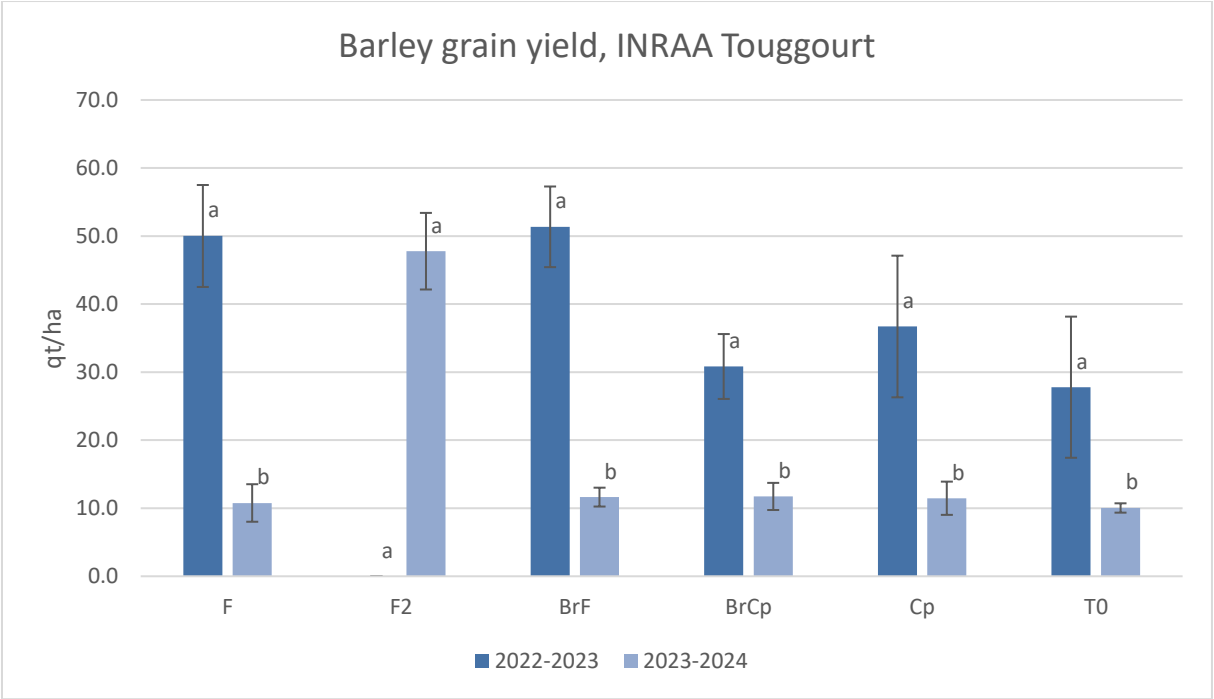

Figure 2: Barley grain yield for the 2022-2023 and 2023-2024 crop seasons, INRAA station of Touggourt. Treatments for 2022-2023: F chemical fertilizers, Br biochar, Cp compost, TO unfertilized control. Treatments for 2023-2024: the same plots were cultivated again in 2023-2024, without renewal of the fertilization (same labels), except F2 which corresponds to plots first cultivated in 2023-2024, with chemical fertilization. Small letters correspond to groups according to Tukey HSD statistical test (discrimination between groups being hampered by the important variability).

For the second year after application, the difference in grain yield between fertilized plots and control plots was much weaker. However, a slight (and statistically unsignificant) improvement of plant

development was observed with addition of biochar versus chemical fertilizer alone, and with either versus unfertilized plots, as well as with compost versus unfertilized plots (grain yield approximately +15%), suggesting some effect of the amendments was still present. Grains were well-formed, with only a slight decrease of the thousand-kernel weight. The grain nitrogen content was similar for all treatments and for both years (Figure 3). Only the grain content in K or P was lower with chemical fertilizer than for the other treatments, confirming the absence of a long-term effect.

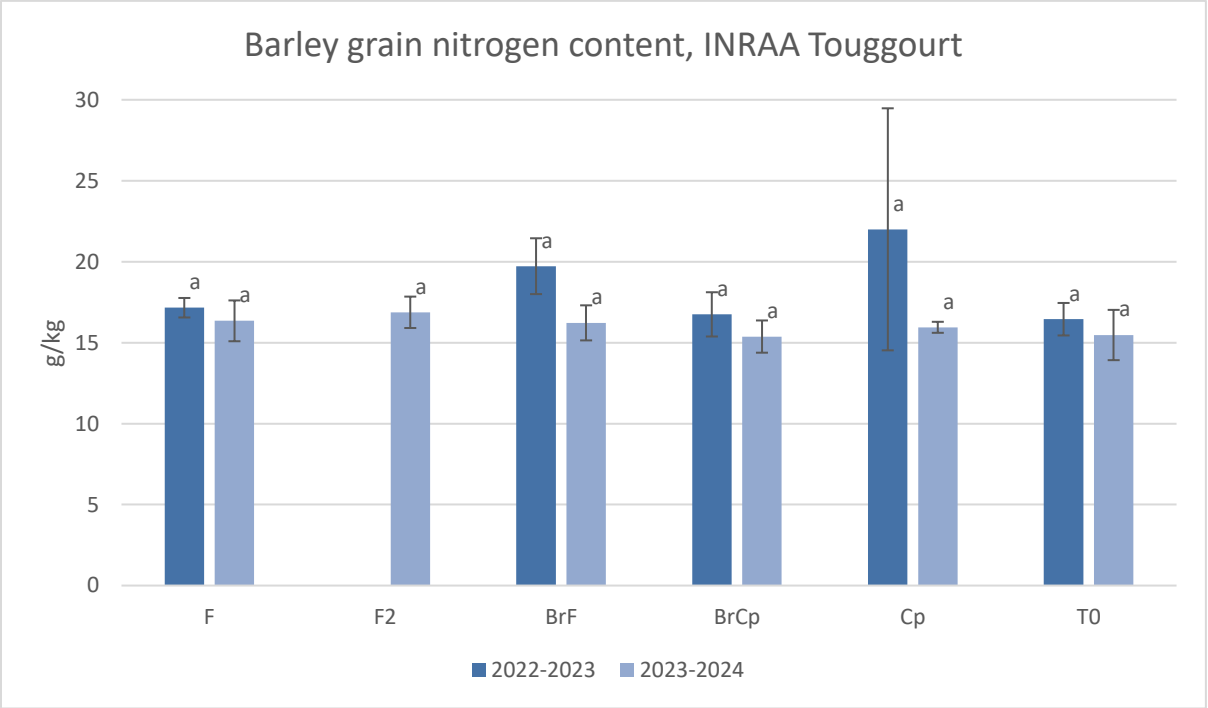

Figure 3: Barley grain nitrogen content for the 2022-2023 and 2023-2024 harvests, INRAA station of Touggourt. Labels are the same as on the previous figure.

The effect on soil organic matter, total nitrogen or phosphorus content (surface horizon), in the first year after application, was highest for compost and to a lesser extent for biochar, whereas chemical fertilizers alone had no effect (Figure 4).

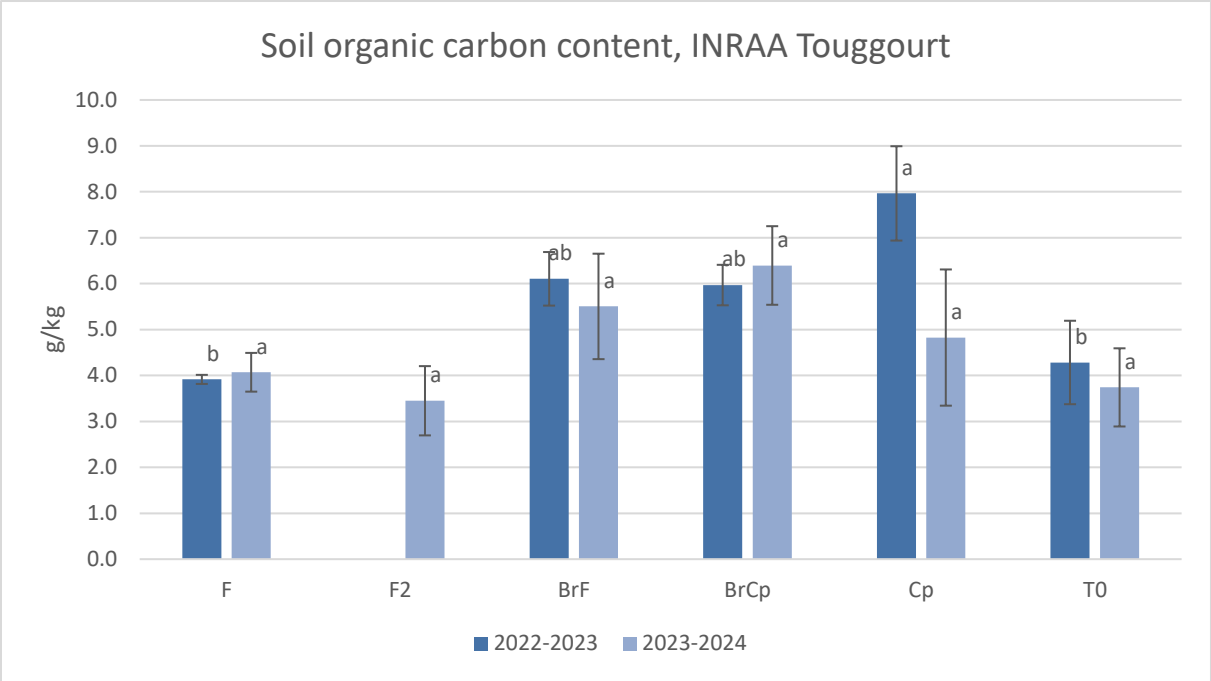

Figure 4: Soil organic matter content at the end of the 2022-2023 and 2023-2024 field trials (0-20 cm horizon), INRAA station of Touggourt. Labels are the same as on the previous figure.

For the second year after application, a clear decline of soil organic carbon content was observed for the compost-only fertilized plots, whereas all other treatments (including biochar+compost) showed no significant change.

Those field results are in good agreement with those of the controlled-conditions incubation and pot cultivation experiments (see deliverables 5.2 and 5.3), in terms of improvement of plant nutrition by compost application but also with regard to the durability of its effects over time. Those indicated that the supply of nitrogen by the compost to the plant is high in the first months but quickly decreases afterwards (likely due to mineral nitrogen loss via leaching), and that an additional source of nitrogen is required on the longer term (or a change of irrigation practices to reduce nitrogen leaching). The loss of nitrogen from compost, unexpected when the protocol was designed, may explain part of the gap between the expected and observed barley yield in the case of compost fertilization.

*In the **IRA station of El Fjé, Médenine**, Tunisia, the 2022-2023 and 2023-2024 trials employed the same treatments as in Touggourt (*

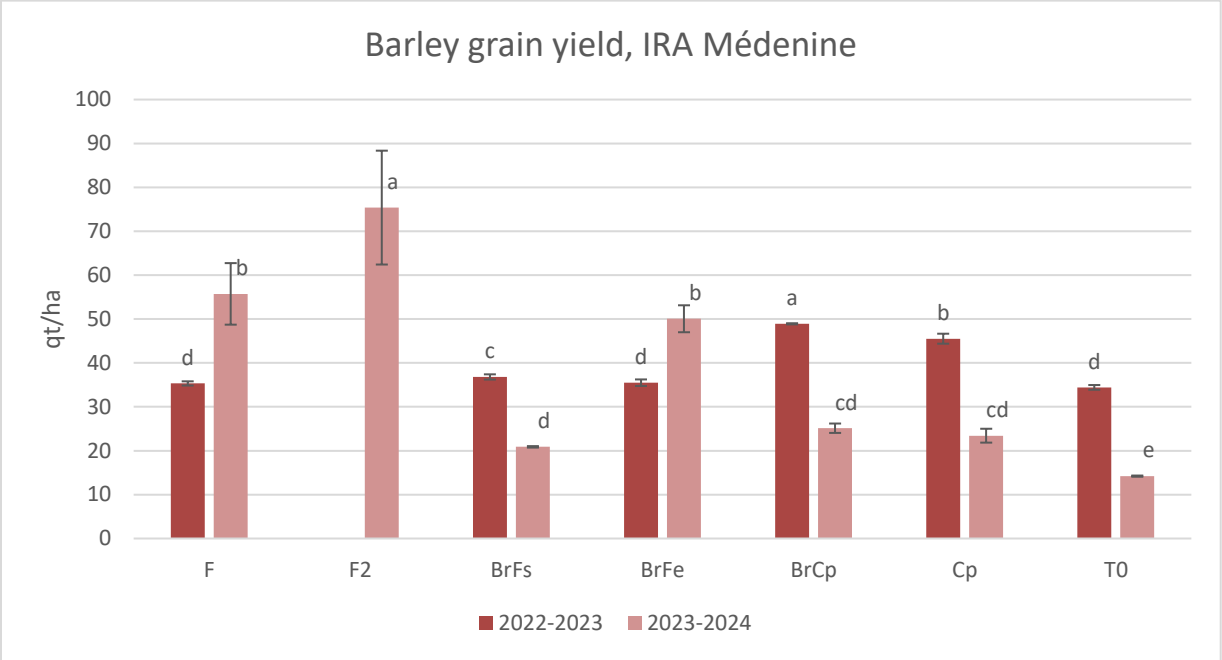

Figure 7), including compost from the ASOC (Gabès) and biochar from the BioFire company (Tébourba). Results of the 2022-2023 crop season were presented at the ISADAE 2024 conference:

Effects of sole and combined addition of biochar and compost on improving soil quality and crop productivity

By H. Oueriemmi, R. I. Zoghlami, A. Bennour, M. Moussa, X. Morvan, M. Ouessar

Figure 5: Plots for the 2022-2023 field trials in El Fjé, Médenine. Six treatments, each comprising 3 replicates, were applied.

Results indicated that soil organic carbon or total nitrogen (Figure 6) was significantly higher for all fertilizer treatments than for control plots. However, the comparison between 2022-2023 and 2023-2024 trials, for soil as well as plant data, is impeded by inconsistencies in the data, likely linked to the plots' cultivation history. For example, the barley grain yield in the 2022-2023 trials (Figure 7) was not

higher for chemical-fertilizer treated plots (either alone or in combination with biochar) than for control plots (around 35 qt/ha, which only compost-treated plots exceeded), suggesting that at least the control plots benefited from earlier amendments, and it increased in 2023-2024 for some treatments although fertilizer supply was not renewed.

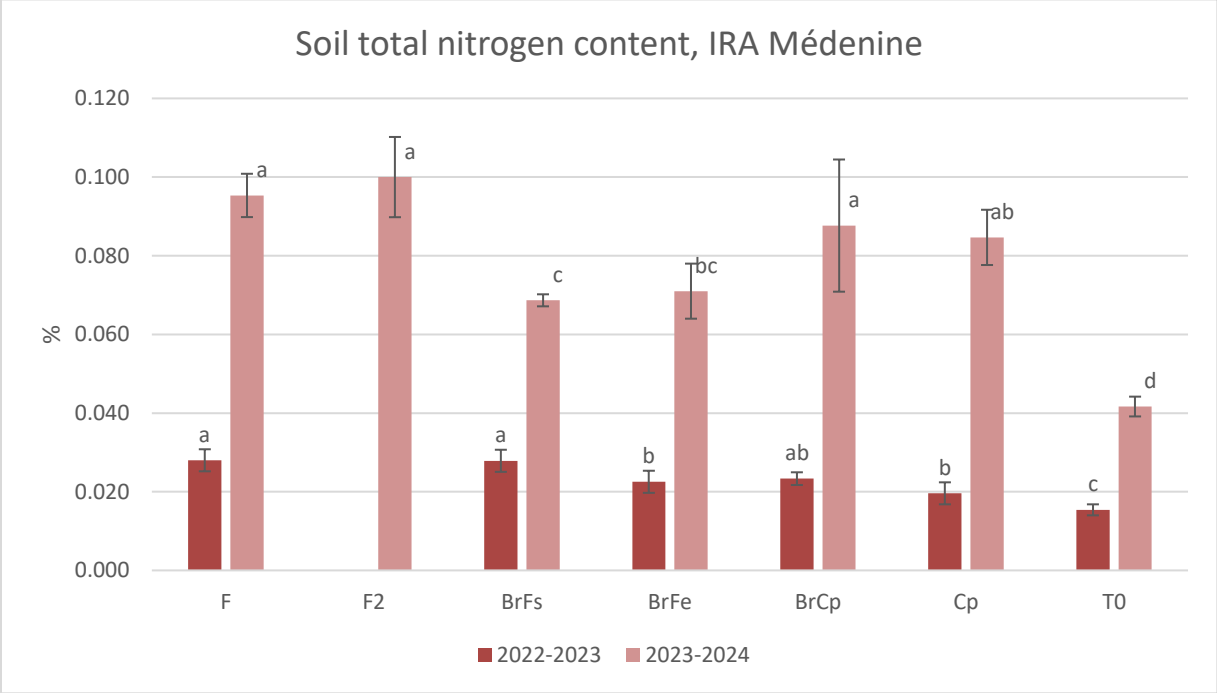

Figure 6 : Total nitrogen content in the soil after harvest. Labels are the same as on previous figure, except: BrFs Biochar and staggered applications of mineral fertilizers, BrFe Biochar previously enriched with fertilizer.

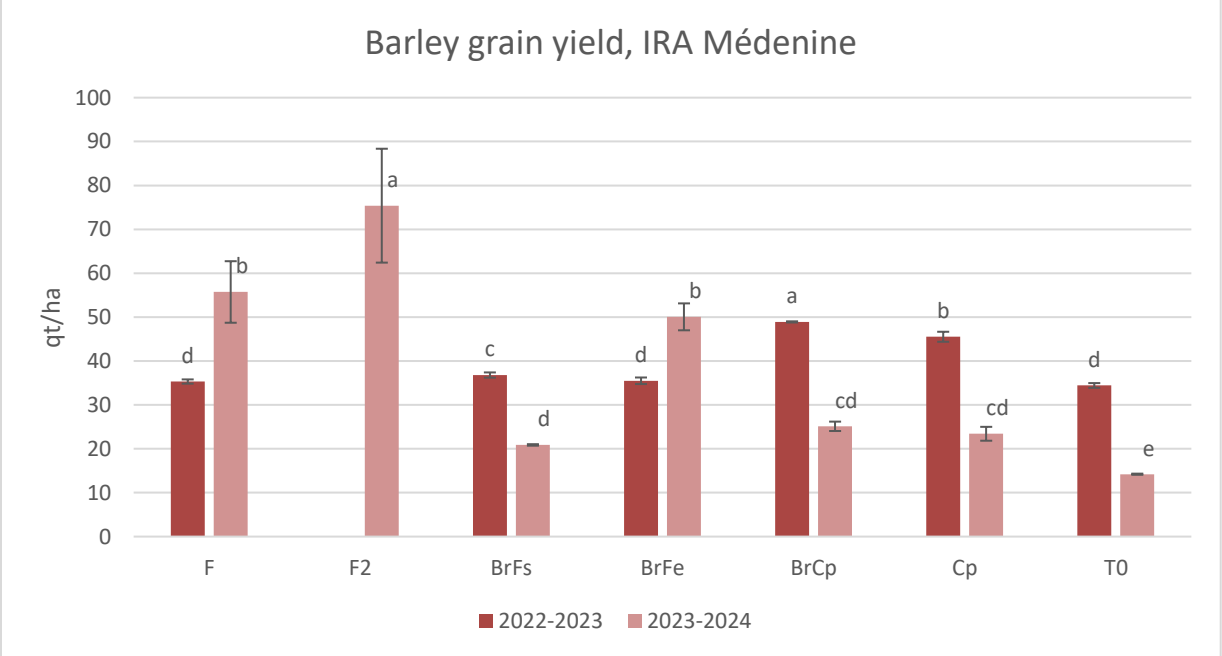

Figure 7 : Grain yield in the El Fjé site during 2022-203 and 2023-2024 crop seasons. Labels are the same as on previous figure.

Additional trials differing from the aforementioned protocol were conducted in the UMKB experimental farm in Biskra and the ITDAS station of Ouargla, Algeria, and in the El Atilet oasis in Kebili, Tunisia.

In the **agronomic station of the UMKB, Biskra**, Algeria, trials suffered from a lack of dedicated qualified manpower, preventing sufficient compliance of the experiments with the common protocol (problems with sowing densities, varying quantities of irrigation water…). Similar problems negatively affected the trials conducted in the **El Atilet oasis in Kebili**. Yet, their results seemed to confirm the positive effect of date palm compost on soil organic matter and, though transiently, nitrogen content. In Kebili, the date yield was evaluated and improved with the tested organic fertilizers.

In the **ITDAS station of Ouargla**, Algeria, the 2021-2022 trials included compost, manure and chemical fertilizers. Compared to the control, the estimated barley grain yields were multiplied by 3, 8 and 11 respectively for compost, manure and chemical fertilizers, reaching 121 qt/ha. These values cast doubt on the reliability of these results. The 2022-2023 trials included compost, chemical fertilizers and compost- or fertilizer-enriched biochar. The barley grain yield for biochar+fertilizer (67 qt/ha) and biochar+compost (53 qt/ha) were higher than for fertilizer alone (45 qt/ha), whereas compost was lower (39 qt/ha), all being higher than the unfertilized control (14 qt/ha). Plant development stages were also a week more precocious for fertilized plots than for unfertilized plots. No data from the 2023-2024 field trials are available to date.