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Research Article

The Effect of Beneficial Autochthonous Microorganisms (Bams) on the Chemical Quality of Agricultural Soils and Olive Production in the Wilaya of Tlemcen (Western of Algeria)

Rachid Dahmani¹, Amine Habib Borsali^{1,2,*}, Abdessamad Merzouk¹, Mohamed Zouidi³,
Sid Ahmed Aouadj¹, Hadj Khatir⁴

¹Research Laboratory of Ecology and Management of Natural Ecosystems, Abu Bakr Belkaid Tlemcen University 13000 – Algeria;

²Laboratory "Water Resources and Environment" Dr. Tahar Moulay University – Saida, Algeria

³Centre de Recherche en Aménagement du Territoire (CRAT) Constantine, Algérie ;

⁴Private scientific consultant and a head of Reprobiotech and Stem Cells Inc. Montréal, Canada;

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Abstract

Beneficial Autochthonous Microorganisms (BAMs) are a multi-purpose technology that has already been used in Latin America and Southeast Asia but is still unknown in Africa and particularly Algeria. The aim is to examine the effect of BAMs on agricultural soils and olive fields. The study was carried out in two degraded olive fields located in the Oued Tafna basin west of Tlemcen (The Semi-arid region in Western Algeria). The objective is to evaluate the effectiveness of BAMs on the chemical characteristics of the soils, particularly in terms of organic matter (MO), pH, electrical conductivity (EC), total limestone (CaCO₃), moisture, organic carbon (C) and olive production and its weight. Statistical analysis (Independent Test) between all groups (treated and controls) showed a significant difference, in conductivity (EC) where we recorded "0.214±0.03µs /cm " in treated soils vs. "0.198±0.029µs/cm " in control soils a different statistical significance was recorded for the other parameters, however, it was observed that there is a relative increase in these parameters in the soils of the treated groups such as carbon (C): "2.85±1.06%" organic matter (MO): "4.91± 1.83%", "pH=7.81±0.225", "CaCO₃ 27.76±4.99% and a decrease in humidity "15.11±3.77%" compared to control soils. The results of statistical analyses (Mann-Whitney Test and Suite Test) of olive production showed a clear alternation (every other year) in fruit production in the control group and a positive effect of BAMs on olive production in the treated group, with a slight increase of production (19 kg in 2019 vs. 30 kg in 2020), but without any significant difference regarding the weight of the fruit between the two sessions. However, a highly significant difference "p=0.00<0.001" in fruit weight was noted between the treated groups "3.908g" and "5.70g" and the control ones "4.40g" and "5.00g" in 2019 and 2020 respectively. The use of MAB is an interesting technique to restore the chemical properties of degraded soils, and increase olive tree production. To achieve more reproducible results (in terms of quantity and quality), sufficient doses of these BAMs and periodicals must be added to provide a good nutritional supplement and reduce farmers' use of pesticides and mineral fertilizers.

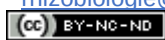
Keywords Agricultural soils, BAMs, chemical properties, olive reproduction, Semi-arid.

Introduction

Algeria has adopted agricultural programs aimed at rebuilding and developing the agricultural

domain, protecting the fragile ecosystem, and reclaiming land for agriculture. However, the effectiveness of these interventions depends on climatic conditions which unfortunately had been neglected in previous national plans. In particular, the reuse of previously farmed land to certain dry or drought-prone lands, replacing cereal cultivation with the cultivation of drought-resistant fruit trees [1]. As a result, Algeria has set up

* Corresponding author: A. H. Borsali, Email:
rhizobiologie@yahoo.fr

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various olive cultivation development projects to increase production and meet market demands. It is well known that the concept of agricultural development for farmers depends on increasing yields, improving product quality, and, above all, maintaining soil fertility by reducing burdens. Therefore, the rehabilitation of degraded agricultural soils and the sustainability of their production is one of the biggest challenges faced by farmers in arid and semi-arid areas. The latter have experienced random exploitation and intensive cultivation by using modern techniques of irrigation, sowing, fertilization, use of heavy agricultural machinery and chemical fertilizers etc., which has led to the degradation of chemical properties and lowered soil fertility, and thus a decrease in yield and the quality of production [2]. The development of new production methods that improve productivity and preserve the environment is therefore a major and urgent priority [3].

In Latin America and South Asia, farmers are opting to use organic fertilizers of plant or animal origin rather than chemical fertilizers because of their low cost and their positive impact on the chemical properties of soil and crops, as well as on groundwater. Among these biological solutions for high use in agriculture in these countries, the beneficial Autochthonous microorganisms (BAMs) are among the most important biological solutions. It is one of the natural biological technologies, of plant origin used in modern agriculture, which consists of a mixture of microorganisms of natural origin, without genetic manipulation and physiologically compatible with each other. Among them and in groups present are photosynthetic bacteria, lactic acid bacteria, actinomycetes, yeasts and break-plicating fungi. These different groups of microorganisms each perform different complementary functions, allowing the synthesis of substances that promote the growth and development of plants, among other properties [4].

Despite the proven effectiveness of this new BAM technology in agriculture, its use in Algeria remains little or not known. Hence the great interest that pushed us to carry out this study in two fields of degraded olive trees in the OuedTafna basin, west of the Wilaya of Tlemcen. The choice fell on the olive tree because it is the dominant agriculture in this area and because several olive plantations have been made in the OuedTafna basin thanks to the policy of development of olive cultivation and the hydro-pedological and geo-morphological context that characterizes this region. To this is added the various environmental problems that have appeared in these fields, in particular the

appearance of indicators of the degradation of the chemical properties of soils by secondary salinization, alkalization, iodization, ... etc. This has led to the death of trees, the yellowing of leaves, and the fall of fruits before maturity and therefore a significant decline in the production and quality of olives. In addition to more drought and diseases of insects and fungi.

This study aims to evaluate the effect of BAMs on olive trees of the "Sigouaze and Vardar" variety, as well as on the chemical properties of the soil. As a result, many issues were raised, including: What is the state of the soil chemical properties of these fields? Is the use of MAB effective in reducing or eliminating indicators of degradation of soil chemical properties in semi-arid areas? Can this technology be used as a biological solution to increase agricultural yield, improve product quality, and reduce environmental problems in semi-arid regions?

Material and Methods

Experimental Parcels

To test our hypotheses, the experimental sites were conducted in two degraded olive fields in the OuedTafna basin west of Tlemcen (Western Algeria) located respectively, (field 01 "SENNAN": N: 34°59'; O: 1°35', with an area of 3ha), (field 02 "TIHATRIT": N: 34°58'; O: 1°34' with an area of 5ha), (Figure1.), with a temperate and warm semi-arid bio-climate. The climate is the Mediterranean, characterized by average annual rainfall of 400 to 600 mm with a seasonal rainfall regime of the HPAE type "precipitation: Winter > Spring >Autumn >Summer", the average annual temperature is 18.73°C with an "m" of 5°C and "M" of 30°C. The experimental sites are located on leached alluvial sedimentary soils with slopes between 1% and 5%. The texture of the surface horizon is limono-sandy called in the local language ("Tiresse or tferchait": bare, lumpy, and stiff soil).

Sampling and choice of stations

In these fields, we randomly selected 10 sampling sites (5 sites that underwent MAB treatment and 5 control sites) of 400 m² each where five olive trees were selected on each site. Five (05) soil samples at each site were randomly collected below each tree during March 2019, after removing litter, at a depth of between 0 and 10 cm corresponding to the organo-mineral surface horizon.

BAMs were placed in designated sites after soil sampling in April 2019 (Figure 6). After one year (April 2020), other samples were taken in the same way and the same place at all treated and

control sites. We also estimated the production of selected olive trees within each site over two years (November 2019 and November 2020) and calculated for each season the average weight of 15 randomly selected fruits of each olive tree.

NB: the plots selected for the study, whether treated or controlled, did not receive any chemical or natural fertilizers during the study period and even before the research. Also, the trees were watered, pruned, and plowed in the same way and at the same time.

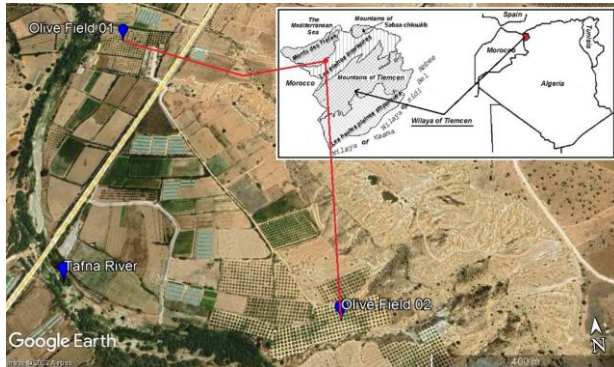


Figure 1. The geographical location of the study sites in the olive groves

Preparation of BAMs

The BAMs were prepared with the native forest litter. The litter is composed of lentisk leaves and oaks, taken from a forest area with little anthropized (Forest of djebelFellaoucene)", brown sugar diluted in water, cornmeal whey, and well water. The litter and cornmeal were first mixed on a plastic sheet until a homogeneous mixture was obtained (Figure 2).



Figure 2. 1st step: mix on a plastic sheet the litter and cornmeal. (Photos authors: March 2019)

Then we added the liquid components (diluted brown sugar, whey, water in small quantities, etc.). Watering the solid phase "litter and Cornmeal" by the liquid phase "Whey and Brown Sugar diluted in water" and stirring for 5 to 10 minutes, first coarsely with a shovel, then more finely by hand, until a mixture is as homogeneous as possible [5, 6]. The final mixture must have a humidity of 40-50% to allow proper fermentation (Figure 3). The resulting mixture is stored in an airtight container. As it was introduced into the container, we compacted it by crushing it with our feet, to drive away the air and guarantee

anaerobic fermentation (Figure 4). The container has been stored away from sunlight and should not be opened or moved for 25 days and at a constant temperature (ideally 27 to 29°C) (Figure 4).



Figure 3. 2nd step: Watering age of the solid phase "litter and cornmeal" by the liquid phase "Whey and brown sugar diluted in water". (Photos authors: March 2019)



Figure 4. 3rd step: The preservation of the mixture in an airtight container at an approximately a constant temperature (ideally 27 to 29 ° C). (Photos authors: March 2019)

Activation of BAMs at a liquid state

In most cases, the composition is converted from solid to liquid (called activated BAM) to multiply it and facilitate its use. The quantities of raw materials used in the preparation of liquid yeast vary depending on the amount to be activated. We add diluted brown sugar, whey, and well water by constantly stirring tout while filling the container (Figure 5). Once the container is full, close it tightly and keep it away from light, for 07 days, without moving it so as not to interfere in the anaerobic fermentation process [5, 6]. After a week the liquid BAMs are ready for use (Figure 6)

[5, 6].



Figure 5. Activation of BAMs at a liquid state
(Photos authors: April 2019)

Figure 6. Implementation of BAMs in designated sites (April 2019). 1- MAB liquids. 2- treated plot and



3- control plot (Photos authors: April 2019).

Treatments

For the liquid activation of the BAMs, we divided the amount of solution added into two parts: we poured 5 liters the first time and after 15 days we added the remaining 5 liters

Soil chemical analyses

The gravimetric water content (% dry mass) was estimated by drying a sample aliquot at 105°C for 24 hours. It was obtained by subtracting the mass of a dried soil sample from that sample before drying. The measurement of the organic matter content by calcination of soil samples at 550 °C and calcium carbonates were determined by Bernard's calcimeter [7].

The pH and electrical conductivity (EC) of the soils were measured in a soil suspension: distilled water (1: 2.5). The measurement was carried out 2 hours after the stabilization at room temperature, using a pH meter "Metrom (Harissa, Switzerland)" and a "conductivity meter". Carbon was calculated as a percentage according to the formula:

$$\ll \frac{\% \text{ organicmatter}}{\% \text{ carbon}} = 1.72 \rightarrow$$

$$\% \text{ carbon} = \frac{\% \text{ organicmatter}}{1.72} \gg [8].$$

Statistical analyzes

Analyses of variance (Independent Test,) were used to determine the chemical properties that explain the effect of BAMs on soils. Analysis of

variance (Mann-Whitney Test and Suite Test) was used to test the influence of BAMs on olive production and fruit weight. The statistical analyses were performed on "Minitab 16" software.

Results

Impact of BAMs on soil chemical properties

The averages of the chemical parameters for all soils in the 2019 study area are recorded in Table 1. Preliminary results show that soils have an organic matter content of more than "6%" and carbon content of "3.72%", which are strongly sealed where the CaCO_3 level is greater than 28%, between " $25 < \text{CaCO}_3 \leq 50$ ", with an alkaline pH " $\text{pH} \geq 8.36$ ", and a humidity level is 11.19%, the conductivity of more than $0.30 \mu\text{S}/\text{Cm}$.

Table 2 summarizes the results of the statistical analyses (Independent test) for the main chemical properties, namely: humidity, organic matter, carbon, pH, electrical conductivity (EC), and total limestone (CaCO_3).

Compared to the results of all samples for the year 2020 (treated and controls), there was a decrease in these characteristics, particularly for pH and EC, carbon content, organic matter, total limestone, and a relative increase in humidity.

Statistical analysis (Table 2) shows that there is no significant difference in the chemical properties of treated and control soils such as Carbon, organic matter, pH, total limestone (CaCO_3) and humidity, which also recorded a significant difference in EC; ' $p = 0,03 < 0,05$ '. The chemical properties of the soils of the treated groups are relatively high compared to the soils of the control groups, including electro conductivity (EC), carbon, and organic matter.

The effect of BAMs on olive production and fruit weight

Effect on production

The third table shows the average yields of olive trees over the two harvest seasons (2019 and 2020) for both groups (treated and controls). The calculated P-value of "Mann-Whitney test" is presented with its significance threshold (*: $P < 0.05$; **: $P < 0.01$; ***: $P < 0.001$; ns: not significant).

NB: The average yield of olive production in the study area in 2018 reached 18.5Kg "source:"Farm of the DAHMANI brothers".

We noted a continuous increase in the premium for the treated group compared to the control, with an estimated reduction of 19 kg and 30 kg vs. 14 and 27 kg in 2019 and 2020 respectively (Table 3).

Table 1.

Results of soil chemical properties in the study area (March 2019)

Chemical Properties	Average calculated (%)
Humidity	11.192
Organic matter	6.395
pH	8.364
Conductivity (EC)	0.336
Carbon	3.722
Total Limestone (CaCO ₃)	28.440

Table 2.

Results of chemical properties of treated soils and Control (Independent Test)

Chemical properties	Treated agricultural soil	Control agricultural soil	T-value and significance
Humidity	15.11±3.77	15.56± 3.64	t = 0.42 ns
Organic matter	4.91±1.83	4.2 ± 0.97	t = 1.81ns
pH	7.81±0.225	7.74±0.162	t = 1.32ns
Conductivity (EC)	0.214±0.03	0.198±0.029	t = 1.95 *
Carbon	2.85±1.06	2.63± 1.21	t = 1.81ns
Total of limestone (CaCO ₃)	27.76±4.99	26.85±4.66	t = 0.67ns

The t-value is presented with its significance threshold (*: P < 0.05; **: P < 0.01; ***: P < 0.001; ns: not significant).

Table 3.

The results of statistical analyses (Mann-Whitney Test) of olive production:

Harvest Year	Median olive production (Kg)		Calculated W-value	Calculated P-value and significance
	Treated Group	Control Group		
2019	19.00	14.25	686.5	0.347ns
2020	30.00	27.00	653.5	0.764ns

The Mann-Whitney Test is presented with its significance threshold (*: P < 0.05; **: P < 0.01; ***: P < 0.001; ns: not significant).

The table 4 below presents the observations of statistical analyses (Test of the suites) of the olive production above or below 20Kg of each tree during the two years of study:

The yield results of the olives for the year 2019 (treated vs. control one) show that most trees did not produce more than 20 kg, compared to the 2020 results.

The number of trees whose production exceeded 20 kg for the treated group reached 16/25 in the last season, while the number reached 13/25 for the control group.

Effects of BAMs on fruit weight

The table 5 presents the medians of olive fruit

weights over the two study years and the calculated P-value of "The Mann-Whitney Test" is presented with its significance threshold (*: P < 0.05; **: P < 0.01; ***: P < 0.001; ns: not significant):

A significant difference in fruit weight between the two "treated and control" groups, whether in the 2019 or 2020 harvest season, was raised.

However, we observed that the average weight of the fruits in the treated group varies significantly "p=0.00<0.05" depending on the treatment over the two harvest seasons, with a weight increase of 1.792g in 2020 from 3.908 g to 5.7 g, without exceeding 5 g in the first season, while most have exceeded this weight of the last season. (Table 6).

For the control group, a significant difference was recorded between fruit weights "p = 0.03 < 0.05",

with a relative increase in 2020 to 5 g.

Table 4.

The results of statistical analyses (Test of suites), of olive production: "Ob. Sup. at 20 Kg: observations greater than 20Kg, Ob. Inf. at 20 Kg: observations less than 20Kg »

Year harvest	Treated Group		Control Group	
	Ob. Sup. to 20 Kg	Ob. Inf. to 20 Kg	Ob. Sup. to 20 Kg	Ob. Inf. to 20 Kg
2019	12	13	11	14
2020	16	9	13	12

Table 5.

Results of statistical analyses (Mann-Whitney Test) of fruit weights over the two harvest seasons

Year harvest	Median Weight of Olive Fruits (g)		Value of P and Meaning
	Treated	Control	
The year 2019	3,908	4,40	0,823 ns
The year 2020	5,70	5,00	0,256 ns
P-value and meaning	0,00***	0,033*	-----

The Mann-Whitney Test is presented with its significance threshold (*: P < 0.05; **: P < 0.01; ***: P < 0.001; ns: not significant).

Table 6.

The results of statistical analyses (Test of suites), weights of olive fruits: "Ob. Sup. at 5g: observations greater than 20Kg, Ob. Inf. at 5 g: observations less than 20Kg »

Year harvest	Treated Group		Control Group	
	Ob. Sup. to 5g	Ob. Inf. to 5g	Ob. Sup. to 5g	Ob. Inf. to 5g
2019	5	20	8	17
2020	20	5	12	13

Discussion

The impact of BAMs on soil chemical properties

The results presented in Table 1 showed that the soil in the study area in 2019 was rich in organic matter, exceeding 6% and a carbon content > 3.5%. This may be due to the natural presence of organic matter of plant or animal origin in the soil prior to sampling.

A decrease in the rate of organic matter was noted in the 2 groups in 2020. Indeed, the organic matter content of the control group soils was less than 4%, due to the relatively high humidity (15.56%) and the absence of plant or animal organic fertilizer during the study period. In other words, for a full year and the organic matter found on these soils results only from fallen olive leaves and branches, and dead roots. This result shows that bacterial activity is limited, and the decomposition of organic matter is slow in these soils. Contrary to what was observed in treated group soils, and despite the presence of BAMs, fallen olive leaves, branches, and dead roots, we recorded a decrease in organic matter from 6.3 9% to 4.91%. This can be explained by the

effectiveness of natural BAMs, which have been added to the soil, and their positive impact on the increase in bacterial activity that has accelerated the decomposition of organic matter with an excess of mineralization which was responsible for the decrease in organic matter rate. Our results agree with those of some researchers who linked the increase in biological activity to the decomposition of organic matter [9], also the modification of the microbial environment in the direction of an efficient microorganism will lead to an acceleration of the fermentation of organic matter and a shortening of the period needed to make high-quality compost [10]. Some authors reported that BAMs are mixed cultures from natural organisms that are highly beneficial to soil health and to increase the microbial ecosystem diversity of the soil (in this case treated soils) [11]. In addition, we noted that treated soils are more fertile, with almost 5% of organic matter compared to untreated ones (only 4%) and higher carbon content (about 3%). Organic matter makes up much of the fertile land and land can become more fertile by increasing its organic matter

content [12, 13].

According to our results, the pH of soils in the study area in 2019 indicated that the soil is alkaline, with a pH of 8.36, and the reason for these findings may be due to the nature of the calcareous soil, where we recorded the calcium carbonate (CaCO_3) level at 28, 44%. It is well known that soil with a high concentration of active lime stone (calcium carbonate) has a high pH (close to 8,2), because the alkaline bases (CaO) that are associated with calcium cations Ca^{+2} raise the pH, making it more alkaline. Indeed [14] argues that the main factor affecting the natural pH of the soil is the geo-material (Soil source material) from which the soil was formed.

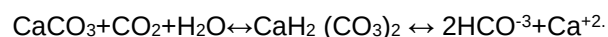
One year after the application of BAMs in the fields, the results of statistical analyses showed that there is no significant difference in the pH between the two "treated and control" groups with a decrease compared to soil pH in 2019, indicating a high concentration of hydrogen in the soil solution. As already mentioned, the effectiveness of BAMs in the treated group is permitted to increase the bacterial activity, accelerate the oxidation of organic matter, and thus increase the CO_2 content in the soil. The CO_2 reacts and dissolves in soil water, forming carbonic acid and hydrogen ions [15], thus lowering the soil pH. In addition, many organic acids such as fulvic acid and humic acid resulting from the oxidation of organic matter drop the pH of the soil. A relatively high pH in treated soils (pH=7.81) may be due to the high level of organic matter, as [16] indicated that organic matter provides a large pH storage capacity in the soil.

However, the decrease in pH in the samples of the control group is plausibly due to the increase in hydrogen ions resulting from the roots of olives. According to [17], when the roots absorb cations such as K^+ , NH_4^+ , Ca^{+2} , Mg^{+3} , or any other cation, an ionic equilibrium must occur inside the root. As a result, the radicals lose part of their hydrogen content to achieve this equilibrium. It also activates the cation exchange between the roots and the clay humic complex (in the presence of water), where the different cations nourishing the plant, in particular Ca^{+2} , are replaced by hydrogen ions " H^+ ". So, the rate of calcium saturation decreases, and therefore the pH decreases [18].

Moreover, we did not observe any significant difference in the percentage of calcium carbonate " CaCO_3 " between the two groups. However, a relative decrease between 2019 and 2020 (the treated group at 27.76% vs. The control group at 26.85%), showed firstly, a high level of H^+ ions in soils, resulting from bacterial activity or cation exchange between the roots and the complex clay humic. The H^+ reacts with calcium carbonate

(CaCO_3) to form water (H_2O), Ca^{+2} , and carbon dioxide (CO_2) [14].

Secondly, the flow and continuous renewal of carbon dioxide (CO_2) in the soil air treated by the action of BAMs allowed calcium carbonate in the presence of water to dissolve in the soil. [15], pointed out that in the presence of CO_2 , the solubility of CaCO_3 is directly influenced by the solubility of CO_2 in water, which transforms it into soluble bicarbonate, which gradually saturates the soil adsorbent complex:



We also reported a decrease in electrical conductivity (EC) in the soil of the studied areas in 2020, particularly in the control group. Several authors explained that the decrease in EC in the soil is due to several reasons, such as precipitation, which causes salts to leach at deeper levels [19], and the great ability of olive trees to concentrate salts in the vicinity of the roots, which are usually 30cm deep, which leads to a decrease in the level of soil salinity in the upper layers [20].

The saturation of the clay-humic complex also leads to the blockage of other mineral elements and their accumulation in the soil in the form of ions such as Ca^{+2} , Mg^{+2} , Na^+ , K^+ , Cl^- , CO_3^{+2} , HCO_3^- , SO_4^{+2} etc, caused a relative increase in electrical conductivity (EC) in the soil in 2019. In general, the richer the solution is in ions or salts, the higher the percentage of electrical conductivity [19], also the results show that there is a direct relationship between organic matter rate and conductivity because the higher the organic matter and the higher the conductivity.

The treatment effect on EC was significant with ($p = 0.037 \geq 0.05$) and was higher in treated soils compared to control soils. The reason for this increase is probably due to the positive effect of MAB on the acceleration of biogeochemical cycles and the formation of mineral elements, also the quality of the added organic matter. This may have contributed to increasing both the cation exchange capacity (ECC) and the temporary stock of cations in the soil. Generally, the richer soil is in clay and organic matter, the greater its CEC and high-CEC soils have higher conductivity than low-CEC soils [21, 22]. In their respective studies, [23] and [24] pointed out that the ability of organic matter to reduce soil salinity depends on the type of organic matter. The reason for the decrease in conductivity (EC) in the control group soils may be due to the decrease in the rate of organic matter and the absorption of salts by olive trees in the vicinity of their roots. This result confirms what has been mentioned above that the

reason for the rise of hydrogen ions in these samples is the absorption of cations by the roots of olive trees such as K^+ , NH_4^+ , Ca^{+2} , Mg^{+3} , or any other cation.

The impact of BAMs on olive production and fruit weight

The average olive production in the fields of study for the 2018 season, reaches 18.5Kg "source: Farm of the DAHMANI brothers". Although we did not record any statistically significant differences between the two groups during the two harvest seasons (2019 and 2020), our results showed that there is a net alternation (every other year) in the production of the control group, so we recorded a decrease in average production by 2 times in 2019 compared to 2020 (14 kg vs. 28 kg), and the number of trees whose average production exceeded 20 kg fruit production was limited to only 13 trees during the two seasons. It is well known that the physiological nature of the olive tree gives an abundant production every other year. Alternation is a peculiarity of the olive tree which can result in a very sharp fall in production every other year [25].

The decrease in production noted in 2019 and its increase in 2020, led to the depletion of most of the nutrient salts in the control soils such as (Ca^{+2} , Mg^{+2} , Na^+ , K^+ , Cl^- , CO_3^{-2} , HCO_3^- , SO_4^{-2} etc.), this confirms what we had previously mentioned regarding the cationic balance between the soil and the roots of olive trees, which was at the origin of the decrease in conductivity and the increase in H^+ in the control samples. Similarly, a statistically significant difference in fruit weight in the two groups was reported. However, we observed that the fruits in the treated group were larger in size and heavier in weight, where the average weight of the fruits in 2020 almost exceeded 6 g.

The positive effect of BAMs on olive production appears especially in the treated group, where we did not record any decrease in production, and it had even had a slight increase in production during the 2019 season to reach 30 kg in 2020 with a few olive trees producing more than 20kg was not negligible. [26] concluded that in the long term, the application of effective BAMs compost could affect the structure of the soil nematode community, wheat biomass, and grain yield.

The positive response of the trees in the BAMs' treated group was also evident in the weight of fruit in g with the years that went from almost single or double. This positive response to treatment is probably due to a good supply of nutrients and the stimulating power of renewal of chemical characteristics in the soil thanks to the biological activity of added BAMs. The latter allowed the olive trees to renew their branches

and bear fruit at the same time. According to Duriez et al [27] if the olive tree is undernourished and/or if it is pruned severely every 2 years, he devotes a year to making wood shoots and a few fruits, then, in the following year, these shoots start to fruit. So that an olive tree is properly maintained and pruned annually, produce every year, except for climatic accidents [27]. Some soil microbes produce certain types of antibiotics that provide nutrients and stimulate plant growth and rhizosphere microbes are known to synthesize plant growth stimulants, ferric acid transporters, and antibiotics, as well as to aid in phosphorus absorption [10].

Conclusions

This present study carried out for the 1st time in the North-West of Algeria has shown that the use of BAMs proves to be an interesting and very effective technique to recover and restore chemical properties in degraded soils, reduce the abusive and harmful use of pesticides, and mineral fertilisers by farmers in Algeria.

From the point of view of fertility, the application of BAMs has helped to increase the level of fertility by accelerating the oxidation of organic matter and gradually reducing the pH, conductivity, and calcium carbonate ($CaCO_3$) content of the soil through the increase of carbon dioxide (CO_2), hydrogen ions (H^+) and activation of cation exchange.

In terms of production, the use of BAMs has increased the amount of production and partially reduced the phenomenon of alternating fruiting. Also, the fruits of the treated group were of better quality in terms of weight, especially in the last season.

To achieve more positive results, sufficient and periodic doses of these BAMs must be added to provide additional food and sufficient energy to make the olive tree bear fruit each year and find a balance between the vegetative and fruitful growth of the tree and make the food stock inside the olive tree suitable for the formation of branches and fruits. The use of effective microorganisms is appropriate to increase mineralization in the composting process, and the compost of the final product can be used without any restrictions.

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