The effect of integrated weed management systems (chemical, biological, directed grazing, and solarization) on soil biological activity and date palm productivity (*Phoenix dactylifera* L.) in Basra.

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Abstract

A field experiment was conducted in the Shatt al-Arab of Basra in a private date palm orchard. The experiment began on June 1, 2024, and ended on December 1, 2025. The aim was to study the effect of four individual factors: solarization (ss), chemical control (cc), fungicide (fc), and directed grazing (gc), as well as the two-factor interactions: solarization + chemical pesticide (sc), solarization + fungicide (sf), and solarization + directed grazing (sg), and the threefactor interaction: solarization + directed grazing + fungicide (sgf).The completely randomized block design (BCRD) was used, and the treatments were randomly distributed. Measurements were taken after the harvest date, and the Triple interaction (sgf) gave the highest significant increase in all experimental treatments for the following traits: total bacterial number ($*10^7$ CFU g soil^{-1}), total fungal number ($*10^3$CFU g soil^{-1}), and date palm yield (kg palm^{-1}), which amounted to 2.685 $*10^7$ CFU g soil^{-1}, 1.2817 $*10^3$ CFU g soil^{-1}, and 124.97 (kg palm^{-1}), compared to the control treatment of 0.0767 $*10^7$ CFU g soil^{-1}, 0.0767 *10 CFU g soil^{-1}, and 94.13 (kg.palm^{-1}).The double interaction (sg) resulted in the highest significant increase in all experimental treatments for the following properties: dehydrogenase, phosphatase, and urease (µmol.g soil^{-1}h^{-1}), (nitrogen, phosphorus, potassium, and organic matter) %, reaching (32.42, 8.18, 42.50, 2.44, 0.66, 0.87, and 2.80)%, respectively, compared to the control treatment (1.37, 0.04, 1.37, 0.11, 0.04, and 0.02)%, respectively.This study highlights the importance of triple interactions in production and duple interactions in soil sustainability and palm production, as well as the importance of directed grazing as an environmentally friendly pest control and fertilization method.

Keywords: Soil enzymes, NPK soil , organic matter, palm rhizosphere.

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Introduction

The world seeks to combat weeds growing in agricultural fields, due to the depletion of nutrients in the soil and the transmission of diseases. In order to preserve soil health and reduce pollution, herbicides for perennial weeds and grasses have been gradually abandoned in favor of agricultural practices and biological techniques to maintain sustainable agriculture (**11**). Palm groves (*Phoenix dactylifera* L.) are among the most important places where the problem of perennial and seasonal narrowand broadleaved weeds is prominent (**14**).A study was conducted to determine the effect of using two types of pesticides: one with the active ingredient glufosinate-ammonium 495 at a concentration of 15 $g.ha^{-1}$ an organophosphorus pesticide), and another with the active ingredient mesulfuron-methyl at a concentration of 15 gram/ha, on the number and activity of bacterial communities in date palm trees. A decrease in the bacterial community was observed, but numbers began to increase after the ninth month of the experiment. This was interpreted as the toxicity of the pesticides diminishing due to their breakdown by soil microorganisms. Since the first pesticide is an organophosphorus pesticide with a structure similar to an amino acid, soil microorganisms break it down amino acid degradation pathways. They remove the amino acid, then the carboxyl group, and finally break the strong phosphoruscarbon bond, releasing phosphorus and forming carbon dioxide. This carbon dioxide then forms unstable carbonic acid, which decomposes rapidly. The net result of this process is nitrogen and phosphorus, and a decrease in soil pH.The soil and the most important bacteria that perform this task *are Pseudomonas* and *Bacillus*, in addition to other fungi, by means of hydrolas enzymes. As for the second pesticide, the role of fungi is greater than the role of bacteria, as they work to break down and decompose this pesticide by secreting hydrolytic enzymes and ultimately produce ammonia. The most famous fungi here are *Aspergillus*, *Trichoderma* and *Penicillium* (**1**).Some studies confirm that soil moisture, soil organic matter content, soil pH and temperature affect the rate of decomposition and breakdown of pesticides (**18**). As an agricultural practice, farm geese have been used to control weeds in agricultural fields as an environmentally friendly method, since the droppings of geese are characterized by organic matter rich in elements such as(nitrogen 3, phosphorus 1, potassium 2 and organic matter 65)% (**34**). The ammonia volatilization from goose droppings into the field space protects the soil ecosystem, especially bacteria and fungi (**36**).

Another environmentally friendly method used was soil solarization to eliminate weeds through direct killing of weeds or thermal stimulation of germination of weed seeds. Perennial weeds have their vegetative part killed, in addition to destroying their vegetative reproductive part, but at the same time it affects the soil ecosystem in general, but it works to reduce soil pathogens (**3**).thiermophiles organisms, such as bacilli, can survive this period of high temperature. After the soil solarization period ends, growth-stimulating organisms spread **(5).** Solarization also increases the accumulation of nitrates, ammonium, and phosphorus in the soil. In general, solarization is an environmentally friendly method that combats stubborn pests **(15).**The use of chemical pesticides of all kinds is the most common method used by farmers to control weeds in palm groves, but it negatively affects the biological community in the field soil. In this scientific paper, a group of single, dual, and triple control methods will be compared to reach the best method that works to preserve the bacterial and fungal community and its effectiveness in the

Materials and Methods

Isolation of *Myrotheciumverrucaria* fungus and preparation of fungal inoculum (FC)

Myrotheciumverrucaria fungus, recently named *Albifimbriaverrucaria*, was isolated from the orchards of Basra. 10 grams of soil with advanced decomposition remains were taken and placed in 90 ml of distilled water. The mixture was then shaken well for 10 minutes using a shaker, resulting in a dilution of 10^{-1}. Further dilutions were then prepared up to 10^{-3}.PDA medium was used, and Chloramphenicol 50 $mg.L^{-1}$ was added to inhibit bacteria, along with Rose Bangal 40 $mg.L^{-1}$ to reduce fungal colony diameters. A sterile glass diffuser was used to diffuse 0.1 ml of the 10^{-3} dilution and incubated at 25-25°C. After 120 hours, white, cottony mycelium appeared, secreting sticky, dark green spores. The isolate was purified, and its morphology was determined under a microscope using an oil immersion lens. The morphology of the spores, appendages, spore-producing cells, and the white margin were observed. The spore shape was spindle-shaped, pointed at both ends, lemon-shaped, and contained an apical appendage. Based on these characteristics **(16)**.The isolation was of the fungus *Myrotheciumverrucaria.* Then 10 liters were prepared in 500 ml flasks containing Dextrose Broth medium with added cellulose. Only 250 ml

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were placed in each flask. Using a new and sterile cork punch, the media were inoculated and then placed in a shaking incubator for five days at a temperature of 26°C. Then the growing colonies were harvested and passed through medical gauze, and the spores were collected in a sterile flask containing 100 ml of deionized water. Then they were counted under the microscope using a special counting slide and with continuous dilution. The number of spores was $4 * 10^{7}$ spores. ml^{-1}.

The chemical pesticide Sandia® (CC)

was obtained from the agents of the American company (Jowan) in Basra. It is a specialized pesticide for the widespread sedge weed in palm groves. Its active ingredient is Sulfonylurea. It is sprayed on all experimental units according to the design at a concentration of 75 $g.ha^{-1}$.

The geese used in the field experiment (gS)

The local geese, 2 months old, of proportionate size, were used in the study area. The number of geese was 25. They grazed in the bushes before chemical control, according to the experimental design, at a rate of half an hour in each experimental unit, three times a day.

soil solarization (SS)

20 micron polyethylene layers were used and the weeds were tightly covered after irrigation to the limits of field capacity and left for 5 weeks in July, so that the soil temperature reached 58°C using a digital thermal conductivity measuring device (Soil test – HI98331) as mentioned in (20).

Experimental Design

The following factors were used Mono: solarization (SS), chemical control (CC), biofungicide (CF), and guided grazing (gc). duple interactions were also used(S+C) chemical pesticide + solarization), F+S (fungicide + solarization), S+G (solarization + guided grazing), and S+G+F (solarization + guided grazing + fungicide). A control group was also included. The factors were randomly distributed across three replicates using an RCBD design. Results were analyzed using SPSS software, and the least significant difference (LSD) was determined at a significance level of 0.05% to establish the significance level between the factors.

Palm Field

A date palm orchard was selected in Shatt al-Arab, Basra, Iraq. The orchard is 15 years old and contains 80 date palm trees. The planting distance between each palm is 6 x 6 meters. The date palm orchard is characterized by uniformity in relative growth. It is irrigated using a bubbler system according to measured water needs throughout the growing season. The experiment began on 1/6/2024 and ended on 1/12/2025.

Etc	Etc	Kc	Eto		Month
108	3.5	1.00	3.5	108	Jan
97	3.5	0.75	4.6	130	Feb
143	4.6	0.75	6.2	191	Mar
0	0	0	0	0	Apr
0	0	0	0	0	May
0	0	0	0	0	Jun
0	0	0	0	0	Jul
0	0	0	0	0	Aug
0	0	0	0	0	Sep
155	5.2	0.70	7.4	222	Oct
103	3.4	0.75	4.6	138	Nov
107	3.5	0.99	3.5	108	Dec

Measured Characters

In the field experiment soil, the organic matter was estimated as % according to the Walkley-Black method. Nitrogen, phosphorus, and available potassium in the soil were estimated after extraction using potassium chloride (2N)KCl with the Kjeldahl Micrometer, following the Keeny-Nielsen method. Available phosphorus was also estimated after extraction using (0.5 M) sodium bicarbonate $NaHCO_3$ according to the Olsen method. The color was developed with ammonium molybdate and ascorbic acid, then determined using a spectrophotometer. Available soil potassium was extracted using the (1 M) NH_4OAC method and then determined using a flame photometer as a percentage in the soil, according to (**20**). The total bacterial count was estimated at 10^7 * CFU. g^{-1} Soil. By dilution and counting in dishes using Nutrient Ager medium, the total fungal counts were estimated at *^{3}10*CFUg^{-1} Soil. By dilution and counting in dishes using Martin's medium, as stated in (**20**).

Detriment of alkaline phosphatase activity:

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The enzyme was Detrimented according to method (**29**) as follows: Incubate (1 g) of soil with (0.2 ml) of stain and (4 ml) of alkaline buffer solution consisting of (12.1 g) Tris(hydroxymethyl)aminomethane(THAM) + (11.6 g) Maleic acid + (14.0 g) Citric acid + (6.3 g) Boric acid dissolved in (488 ml) of sodium hydroxide (1 M), bring the pH to 11, then complete the volume to 1 liter using (0.1 M) NaOH, then add 1 ml of the control material NO2C2H4OPO2Na2.6H2O4-nitrophenyl phosphate Hexahydratedi-sodium dissolved in an alkaline buffer solution with a concentration of (0.05 M). The mixture was then incubated at 37°C for one hour. Immediately after incubation, 1 ml of CaCl2 (0.5 M) and 4 ml of NaOH (0.5 M) were added. The solution was then filtered through Whatman No. 42 filter paper, and 1 ml of the filtrate was taken and its yellow color was measured using a spectrophotometer at a wavelength of 420 nm.

Detriment of urease enzyme (µgN-NH4+ g^{-1} soil, $2h^{-1}$)

Weigh (5)g of soil was placed in a (50) mL volumetric flask. (0.2)mL of stain, (9)mL of the buffer (tris) hydroxylmethylaminomethane (pH 9), and 1 mL of(0.2) M urea were added as a control. The samples were incubated at 37°C for 2 hours. Then, (35) mL of (2.5) M potassium chloride solution and (100) ppm silver sulfate were added as an inhibitor. The volume was then brought up to (50) mL with the same buffer. The ammonium nitrogen produced by the enzyme's activity was estimated using steam distillation with magnesium oxide and boric acid, according to method (**28**).

Detriment the activity of the dehydrogenase enzyme:

Weigh (6) grams of soil and place it in a centrifuge tube. Add (0.1) grams of calcium carbonate and mix well. Then add (1 ml) of TTC reagent at a concentration of (3%). Then add (2.5 ml) of distilled water and place it in a shaker. Then close it tightly and wrap it with aluminum foil. Then incubate for 24 hours at a temperature of 37°C. Then add 10 ml of 95% methanol. Then shake for several minutes until the red color appears. Then filter it through filter paper and centrifuge at 3000 rpm for five minutes. Then collect the clear liquid and reach 50 ml. A Planck sample was used and the absorbance was measured in a Spectrophotometer, type 1100, American, at a wavelength of 485. The standard curve was made, and using a special equation, the enzyme activity was estimated (micrograms TPF. g soil $^{-1}$, 24 h $^{-1}$) as in (**28**).

Results and discussion

The results of the analysis of variance (ANOVA) in Table (2) showed that the mono factors of the chemical pesticide (CC), the fungicide (FC), and solarization did not achieve any significant increase in the total bacterial count, except for the directed grazing treatment with geese (gc), which showed a significant increase ($P \leq 0.05$) in the total bacterial count (*10^7 CUF g soil^{-1})

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in the root zone of the palm trees. These results indicate that the highest significant increase in the mono factors was in the (gc) treatment, as directed grazing using geese led to a significant increase in the total bacterial count. The least significant difference ($LSD_{0\ ,0\ 5}$) test helped clarify the differences between the treatments, as the results showed a significant advantage in bacterial count in the (gc) treatment, reaching $0.59*10^7$ CUF g soil^{-1}, compared to the control treatment of $0.15*10^7$ CUF g soil^{-1}. 7CUF grams of soil $^{-1}$. The difference between the values of the two levels is $0.8 * 10^{-7}$ 7CUF g of soil $^{-1}$, which is higher than the value of (LSD =).The results of the binary treatment interactions (SC) solarization + chemical pesticide, (SF) solarization and fungicide, and (SS) solarization showed no significant effects for any of the treatments at a significance level of ($P \leq 0.05$), except for the binary interaction treatment (Sg) solarization + fungicide, which gave an increase at a significance level of ($P \leq 0.05$) in the total bacterial count. It became clear that the interaction between directed goose grazing and the fungicide led to an increase in the total bacterial count in the root zone of the palm, which confirms that directed grazing was able to increase the number of bacteria present in the soil of the palm roots, reaching $1.54*10^7$ CUF g soil^{-1}, compared to the control of $0.59*10^7$ CUF g soil^{-1}. The difference between the two levels was $0.95*10^7$ CUF g soil^{-1}, which is higher than the value of (LSD =0.457) which confirms that solar sterilization has led to the elimination of antibacterial pathogens and increased the availability of nutrients due to the high temperature and its effect on the release of nutrients from the soil, which provided nutrients that bacteria can use to build their bodies, especially phosphorus, nitrogen, zinc and iron (**15**).The fungicide also led to the breakdown of weed residues in the soil, particularly cellulosic tissues, converting them into organic compounds that the soil bacterial community can utilize as an energy source **(23 and 39).** The triple interaction (SGF) of solarization, directed goose grazing, and a biofungicide for weeds achieved the highest significant increase in total bacterial counts in the field experiment ($P \leq 0.05$). The treatment reached 2.68×10^7 CUF g soil^{-1}, compared to the control treatment of 0.15×10^7 CUF g soil^{-1}. The difference between the two levels was 2.53×10^7 CUF g soil^{-1}, which is higher than the LSD value. This confirms that solarization, directed grazing, and the biofungicide for weeds led to an increase in total bacterial counts in the soil. This triple interaction can be explained by Soil bacteria were able to obtain the nutritional requirements of carbon, nitrogen, phosphorus, potassium, sulfur, iron, zinc, and others under the conditions suitable for continuing to coexist and reproduce in the palm rhizosphere (**30**), in addition to the enzymes and vitamins carried by goose droppings to fertilize the soil when irrigated (**27**). In addition to the contribution of fungi in breaking down the tissues of weed remains and converting them into simpler materials that can be used by organisms in the soil, including bacteria (**16 and 38**).results for

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the binary treatment interactions (SC) solarization + chemical pesticide, (SF) solarization and fungicide, and (SS) solarization all showed a significant increase at a significance level of ($P \leq 0.05$). It became clear that the interaction between directed goose grazing and fungicide led to the highest significant increase in the total number of fungi in the root zone of the palm, and the highest increase was observed in the binary interaction treatment (Sf). This confirms that directed grazing with the chemical herbicide was able to increase the number of fungi present in the soil of the palm roots at a depth of 30 cm, reaching 2.31 * 10^{-3}CUF g soil^{-1} compared to the control 0.07 * 10^{-3}CUF g soil^{-1}. The difference between the two levels was 0.95 * 10^{3}-CUF g soil-a, which is higher than the value of (LSD=2.24), which confirms that solar sterilization has led to the killing of pathogens that limit the number of fungi in the soil after the temperature reached more than 58 degrees Celsius in our study, which excluded fungi and organisms resistant to high temperatures. This led to a high activity of these organisms in breaking down the plant residues present in the soil (**5**). In addition, spraying the soil with a fungicidal herbicide 10 days after removing the cover to allow the remaining weeds to grow led to them being attacked by the fungus Myrotheciumverrucaria and breaking down cellulose compounds (**17**).In addition to the goose droppings that improve soil properties, especially chemical and biological ones, as they add biochemical substances beneficial to the soil and organisms, such as vitamins, enzymes, and micronutrients, especially zinc and iron, which are utilized by the soil's biological community, including fungi (**37**). As for the triple interaction (SGF) solarization + directed goose grazing + biofungicide for weeds, it achieved the highest significant increase in the field experiment at ($P \leq 0.05$) in the total bacterial count, as the treatment reached 1.28 * 10^{-3}CUF g soil^{-1} compared to the control treatment 0.07 * 10^{-3}CUF g soil-a, as the difference between the two levels was estimated at 1.21 * 10^{-3}CUF g soil^{-1}, which is higher than the value of (LSD =0.2699).This confirms that solarization, controlled grazing, and the application of fungicides to weeds led to an increase in the total number of fungi in the soil. This Triple interaction can be explained by the fact that the total fungi in the soil, supplemented with saprophytic fungal inoculum, were able to adapt to the soil and effectively decompose cellulosic compounds along with goose droppings, which are rich in macronutrients and some micronutrients important for the soil and living organisms. This increased the soil's fertility (**22**). It was observed that the total fungal count in the single treatment (sf), amounting to 2.31 x 10^{-3}CUF g soil^{-1}, was greater than in the triple interaction treatment (sgf), amounting to 1.28 x 10^{-3}CUF g soil^{-1}, despite the absence of organic goose droppings. This may be because the soil fungi were able to benefit from the abundance of nutrients and the decomposition of organic matter. In addition, the addition of the effective fungal inoculum to the soil increased the number of fungi in the soil.

ISSN 2072-3857

Table 2 .shows the effect of the treatments on the total numbers of bacteria and fungi.

Total fungi CFU.g^{-1} $*10^3$	Total bacteria CFU.g^{-1} $*10^7$	Treatment
1.2817	2.685	Sgf
1.0883	1.5417	Sg
0.1367	0.5917	Gc
1.4833	0.35	Fc
2.315	0.2883	Sf
1.4017	0.4817	Ss
0.0767	0.1517	Control
0.9883	0.105	Cc
0.9433	0.1117	Sc
0.2699	0.457	**LSD (0.05)**

The results of the analysis of variance (ANOVA) in Table (3) showed that the mono factors of the chemical pesticide (CC), the fungicide (FC), and solarization (ss) all achieved a significant increase in dehydrogenase enzyme activity (µg TPF.g soil $^{-1}$ 24h $^{-1}$), except for the treatment (gc) directed grazing, which did not achieve a significant increase in dehydrogenase enzyme activity (µg TPF.g soil $^{-1}$ 24h $^{-1}$). The highest values of the treatments at the significance level ($P \leq 0.05$) in dehydrogenase enzyme activity content were in the rizospher of palm trees. The least significant difference test ($LSD_{0,05}$) helped to clarify the differences between the treatments.The results showed a significant increase in dehydrogenase enzyme activity, reaching 29.28 (µg TPF.g soil $^{-1}$.24h $^{-1}$) compared to the control of 1.37 (µg TPF.g soil $^{-1}$.24h $^{-1}$). The difference between the two levels was 27.91 (µg TPF.g soil $^{-1}$.24h^{-1}), which is higher than the (LSD=). These results indicate that the highest significant increase in individual factors was in the (gc) treatment. It was found that directed grazing using geese led to a significant increase in dehydrogenase enzyme activity because when organic matter is added to the soil, the enzyme plays a pivotal role in increasing the respiration of organisms, and consequently, the proliferation of the microbial community results in high enzyme secretion from within the microbial organisms (**19**). As for the

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results of the binary treatment interactions (SC) solarization + Chemical pesticide and (SF) solar sterilization, and fungicide and (SS) solar sterilization.

Significant effects were observed for all treatments at a significance level of ($P \leq 0.05$). The treatment (sg) resulted in the highest increase at a significance level of ($P \leq 0.05$) in dehydrogenase enzyme activity. It was found that the interaction between solarization and directed goose grazing led to an increase, reaching 32.42 (µg TPF.g soil $^{-1}$.24h $^{-1}$) compared to the control treatment (µg TPF.g soil $^{-1}$.24h $^{-1}$). The difference between the two levels was 31.05 (µg TPF.g soil $^{-1}$.24h $^{-1}$), which is higher than the(LSD =) of 3.4066. This confirms that solarization and the weed fungicide led to an increase in dehydrogenase enzyme activity related to the production of this enzyme by microorganisms, and not just in the number of microorganisms. Bacteria and fungi, meaning that there are factors that prevent microorganisms, despite their presence, from producing the enzyme, including the residue of the herbicide (**21**).As for the triple interaction (SGF) solarization + directed goose grazing + biofungicide for weeds, it did not achieve a significant increase in the field experiment at ($P \leq 0.05$) in the activity of the dehydrogenase enzyme, and the reason may be that there are functional groups active in the humus resulting from goose droppings that are linked to the enzyme molecules by ionic or hydrogen bonds, or that the enzyme is linked to the clay, so its activity decreases (**2 and 34**).

The results showed that the mono treatments of the chemical pesticide (CC) and solarization (ss) did not significantly increase the activity of the phosphatase enzyme (µg *P*-nitrophenol g^{-1} soil h^{-1}). However, the fungicide treatment (FC) and the directed grazing treatment (gc) significantly increased the activity of the phosphatase enzyme (µg *P*-nitrophenol g^{-1} soil h^{-1}). The highest values of the two treatments were observed in the directed grazing treatment (gc) at a significance level of ($P \leq 0.05$) in the phosphatase activity content in the root zone of palm trees at a depth of (30 cm). The least significant difference ($LSD_{0,05}$) test helped clarify the differences between the treatments, with the results showing a significant increase in phosphatase activity, reaching 7.40 (µg*P*-nitrophenol g^{-1}). Soil at 1 hour compared to the control treatment (0.04 µg *P*-nitrophenol g^{-1} soil h^{-1}). The difference between the two levels was greater than the value of (LSD = 7.36) µg *P*-nitrophenol g^{-1} soil h^{-1}).These results indicate that the highest significant increase in individual factors was observed in the (gc) treatment. Directed grazing using geese significantly increased phosphatase activity. This increase is likely due to the addition of organic matter, which stimulated the growth of the microbial community and increased the activity of exogenous metabolism, including enzymes (**13, 26**). The results of the binary treatment interactions (SC) solarization + chemical pesticide and (SF) – solarization + fungicide did not significantly increase phosphatase activity. However, the (Sg) treatment did

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significantly increase phosphatase activity. The interaction between solarization and directed geese grazing resulted in an increase in phosphatase activity, reaching 8.18 µg *P*-nitrophenol g^{-1} soil h^{-1}, compared to 0.04 µg *P*-nitrophenol g^{-1} control. The difference between the two levels was 8.18 micrograms of *P*-nitrophenol g soil h^{-1}, which is higher than the value of (LSD= 1.9228), confirming the effectiveness of solarization and the herbicide.This has led to an increase in the activity of the phosphatase enzyme, because solarization and the rise in temperatures have led to an increase in the availability of nutrients needed by the biological community, in addition to the breakdown of plant tissues by the fungus and its conversion into energy and carbon compounds that are utilized by the growing biological community, which secretes the phosphatase enzyme, thus harmonizing with the increase in the numbers of the bacterial and fungal community in the soil in our study (**1 , 4).**The triple interaction (SGF) of solarization, directed grazing, and a biofungicide for weeds achieved the highest significant increase in phosphatase activity in the field experiment ($P \leq 0.05$). The treatment with 6.70 µg *P*-nitrophenol g^{-1} soil h^{-1} increased activity compared to the control treatment of 0.04 µg *P*-nitrophenol g^{-1} soil h^{-1}. The difference between the two levels was 6.66 µg *P*-nitrophenol g^{-1} soil h^{-1}, which is higher than the LSD value (LSD = 1.9228). This confirms that solarization, directed grazing, and the biofungicide for weeds led to increased phosphatase activity in the soil. This triple interaction can be explained by the fact that the added organic matter contains phosphorus bound to the organic matter, thus promoting the growth of microorganisms, especially beneficial bacteria. For growth, this enzyme is secreted to release it from organic matter, which led to an increase in the enzyme's effectiveness (**23 ,37**).The results in the same table also showed that the mono factors of the chemical pesticide (CC), solarization (ss), and fungicide (FC) did not achieve a significant increase in the activity of the urease enzyme (µgN-NH_4^+ g^{-1} soil. $2h^{-1}$). However, the (gc) directed grazing treatment achieved a significant increase in the activity of the urease enzyme at a significance level of ($P \leq 0.05$) in the urease enzyme activity content in the root zone of palm trees at a depth of (30 cm). The least significant difference test ($LSD_{0.05}$) helped to clarify the differences between the treatments, as the results showed a significant superiority in the activity of the urease enzyme, reaching 30.17 (µgN-NH_4^+ g^{-1} soil. $2h^{-1}$).Compared to the control treatment 1.37(µgN-NH_4^+ g^{-1} soil.$2h^{-1}$), the difference between the two levels was 28.8(µgN-NH_4^+ g^{-1} soil.$2h^{-1}$), which is higher than the value of (LSD = 5.0617). These results indicate that the highest significant increase in the individual factors was in the (gc) treatment, as it became clear that directed grazing usinggeese led to a significant increase in the activity of the urease enzyme. Perhaps the reason for the increase is that the addition of organic matter loaded with uric acid encouraged the biotic community to grow and

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increase the production of the urease enzyme (**6**).The results of the binary treatment interactions (SC) solarization + chemical pesticide and (SF) solarization and fungicide did not achieve a significant increase in urease enzyme activity. As for the triple interaction (SGF) solarization + directed goose grazing + biological fungicide for weeds, it did not achieve a significant increase in urease enzyme activity in the field experiment at ($P \leq 0.05$), and the reason may be the functional groups in the organic matter resulting from directed goose grazing (**34**) or the functional groups of the pesticide that bind to and restrict the enzyme (**2**).

Table 3 the effect of the treatments on enzyme activity.

Treatment	**Urease**	**Phosphatase**	**Dehydrogenase**
Sg	42.50	8.18	32.42
Gc	30.17	7.40	29.28
Fc	8.25	5.90	28.42
Sgf	5.95	6.70	1.88
Ss	1.47	2.02	4.02
Cc	0.88	2.16	0.40
Sf	5.85	0.13	1.54
Sc	3.27	0.62	1.47
Control	1.37	0.04	1.37
LSD (0.05)	5.0617	1.9228	3.4066

The results of the ANOVA for Table (4) show that the general trend for nitrogen and potassium levels is consistent across all treatments. The mono chemical pesticide (CC) did not significantly increase available nitrogen (N%). However, the fungicide (FC), solarization (SS), and directed grazing (GC) treatments did significantly increase available N%. The highest values were observed in the (SS) treatment at a significance level of ($P \leq 0.05$) for soil nitrogen content in the root zone of date palm trees at a depth of (30 cm). The Least Significant Difference (LSD) test further clarified the differences between the treatments, with an increase of 2.14% compared to the control 0.11%. The difference between the two levels is 2.08%, which is higher than the (LSD =0.6906).These results indicate that the highest significant increase in individual factors was observed in the (SS) treatment. Solarization significantly increased soil nitrogen, possibly due to higher temperatures which increase the availability of ammonium moving from within or on soil particles into the soil solution (**12**). Regarding the results of the binary treatment interactions, (SC) solarization + chemical pesticide did not significantly increase soil nitrogen availability, unlike (SF) solarization and fungicide, and (Sg) solarization, which achieved significant increases at a significance level of ($P \leq 0.05$). The highest increase at a significance level of ($P \leq 0.05$) was observed in the (Sg) treatment. Furthermore, the interaction between solarization and directed goose grazing resulted in an increase of 2.44%, compared to 0.11% in the control treatment. The difference between the values was significant. The two levels are 2.33, which is higher than the value of (0.6906) LSD, which confirms that solar sterilization and the fungicide, perhaps due to the enzymes secreted by the fungicide, as it secretes the urease enzyme, which converts organic nitrogen in the soil into ammonium **(1)**.The triple interaction (SGF) solarization + directed goose grazing + biofungicide for weeds achieved a significant increase in soil nitrogen availability in the field experiment ($P \leq 0.05$), reaching 2.46%. This is compared to the control treatment (0.11%), with a difference of 2.33%, which is higher than the LSD value (0.6906). This is attributed to the nitrogen-rich organic matter and the fungus's effectiveness in converting urea to ammonium in the soil solution (**10, 16**).The results of the analysis of variance (ANOVA) show that potassium results followed the same trend in all treatments as available potassium. The individual chemical pesticide (CC) did not significantly increase available nitrogen (N%), while the fungicide (FC), solarization (ss), and directed grazing (gc) treatments significantly increased available potassium (K%). The highest values in the treatments were observed in the (FC) treatment at a significance level of ($P \leq 0.05$) for soil nitrogen content in the root zone of date palm trees at a depth of 30 cm. The least significant difference (LSD) test helped clarify the differences between the treatments, reaching 0.90% compared to the control treatment (0.04%). The difference between the two levels is 0.86%, which is higher than the LSD value of 0.1771. These results indicate that the highest significant increase in the individual factors was observed in the (FC) treatment, as it turned out that the fungicide led to an increase in the soil's potassium content, perhaps because the fungus attacks weed cells and breaks down food vacuoles, which causes potassium to come out into the soil (**25**).Regarding the results of the binary treatment interactions, (SF) (solar sterilization and fungicide) and (SC) (solar sterilization + chemical pesticide) did not achieve a significant increase in available soil nitrogen, unlike (Sg) (solar sterilization), which achieved a significant increase at a significance level of ($P \leq 0.05$). The highest increase at a significance level of ($P \leq 0.05$) in nitrogen concentration was observed in the (Sg) treatment. It was found that the interaction between solar sterilization and directed goose grazing led to an increase, reaching 70.8% compared to the control treatment of 0.11%. The difference between the two levels was 77.0, which is higher than the (LSD= 0.1771). This confirms that solar sterilization and the fungicide increased available soil potassium due to their killing of pathogens and weeds that deplete a large percentage of available potassium (**35**). The triple intervention (SGF) of solarization + directed goose grazing + biofungicide for weeds achieved a significant increase in soil potassium availability in the field experiment ($P \leq 0.05$), reaching 0.59%. This is compared to the control treatment (0.11%), with a difference of 0.48%, which is higher than the LSD value (0.1771). This is attributed to the potassiumrich organic matter and the fungus's effectiveness in releasing potassium from the vacuoles and cytoplasm of the weed cells it attacks into the soil solution (**10**).

The results of the analysis of variance (ANOVA) showed that the available phosphorus (P) percentage in the soil was not significantly increased by the mono factors: chemical pesticide (CC) and sterilization (SS). However, the fungicide (FC), (gc), and directed grazing treatments significantly increased available P percentage. The highest values were observed in the (gc) treatment at a significance level of ($P \leq 0.05$) for soil nitrogen content in the root zone of date palm trees at a depth of 30 cm. The least significant difference (LSD) test further clarified the differences between the treatments, with a value of 0.85% compared to the control treatment of 0.02%. The difference between the two levels is 0.83%, which is higher than the(LSD =0.6146). These results indicate that the highest significant increase in the individual factors was observed in the (gc) treatment. It turned out that the fungicide led to an increase in the soil's phosphorus content because the organic matter, which is goose droppings, is rich in phosphorus, as the biological community breaks down organic compounds and releases elements from them (**32**).As for the results of the duple treatment interactions, (SC) solarization + chemical pesticide did not achieve a significant increase in available phosphorus in the soil, unlike (Sg) solarization. (SF) solarization and fungicide achieved a significant increase at a significance level of ($P \leq 0.05$), with the highest increase at a significance level of ($P \leq 0.05$) in phosphorus concentration observed in the (Sg) treatment. It became clear that the interaction between solarization and directed goose grazing led to an increase in available phosphorus % in the soil, amounting to 0.66% compared to the control treatment of 0.04%. The difference between the two levels was 0.62%, which is higher than the value of (LSD = 0.2483).This confirms that solarization and fungicide increased the available phosphorus in the

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soil. Solarization kills pathogens, and the fungicide breaks down cellulose if it is weeds, converting organic matter into simpler structures. It then secretes the phosphatase enzyme, which breaks down organic matter and releases phosphorus into the soil (**6**). However, the triple interaction (SGF) of solarization + directed goose grazing + biofungicide for weeds did not achieve a significant increase in soil phosphorus availability in the field experiment ($P \leq 0.05$). This may be due to the addition of the biofungicide before covering with plastic, as heat accelerates phosphorus fixation by calcareous soils in our field experiment (**2**).Regarding the results for soil organic matter (OM) content, the mono factors—chemical herbicide (CC), fungicide treatment (FC), and sterilization (SS) did not significantly increase OM%. Only directed grazing (gc) resulted in a significant increase in OM at a significance level of ($P \leq 0.05$) in the root zone of palm trees at a depth of 30 cm. The least significant difference ($LSD_{0.05}$) test further clarified the differences between the treatments, with an increase of 3.37% compared to the control treatment of 0.24%. The difference between the two levels is 0.59%, which is higher than the (LSD =0.6146). These results indicate that the significant increase in individual factors was only observed in the gc treatment, as the fungicide was found to have led to an increase in OM%. O.M. due to regular and directed grazing of geese (**31 ,33).**As for the results of the interactions of the two treatments, the treatment (SF) solar sterilization and fungicide and (SC) solar sterilization + chemical pesticide did not achieve a significant increase in O.M% in the soil, unlike (Sg) solar sterilization and directed grazing with geese, which achieved a significant increase at a significance level of ($P \leq 0.05$), as it reached 2.80% compared to the control treatment of 0.24%, as the difference between the value of the two levels was 2.04%, which is higher than the value of (LSD =0.6146) which confirms that solar sterilization killed many of the pathogens and they were transformed by the heat into organic matter with different degrees of decomposition, in addition to the geese adding quantities of organic matter to the soil (**37**).The triple intervention (SGF) solarization + directed goose grazing + biofungicide for weeds achieved a significant increase in O.M % in the field trial soil at ($P \leq 0.05$). The treatment reached 2.70% compared to the control treatment of 0.24%, with the difference between the two levels amounting to 2.49%, which is higher than the value of (LSD = 0.6146). This confirms that the triple intervention led to a significant increase in O.M % due to the addition of geese, the decomposition of plant tissues by the fungus, and the high temperatures of solarization, which killed weeds and pathogens, leading to an increase in the soil's organic matter content (**15**).

ISSN 2072-3857

Table 4. the effect of the treatments on the soil content of NPK and organic matter.

Treatment	**OM%**	**K%**	**P%**	**N%**
Sg	2.80	0.87	0.66	2.44
Sgf	2.70	0.59	0.17	2.64
Gc	3.37	0.85	0.77	1.53
Fc	0.18	0.90	0.25	1.88
Ss	0.19	0.10	0.09	2.14
Sf	0.26	0.31	0.16	2.25
Sc	0.28	0.29	0.34	0.52
Cc	0.10	0.29	0.04	0.39
Control	0.24	0.02	0.04	0.11
LSD (0.05)	0.6146	0.1771	0.2483	0.6906

The results in Table 5 indicate the yield of date palms ($kg.palm^{-1}$). The mono factors, chemical pesticide (CC) and sterilization (SS), did not significantly increase OM%. However, the fungicide (FC), (gc), and directed grazing treatments significantly increased the yield of date palms ($kg.palm^{-1}$) at a significance level of ($P \leq 0.05$). Treatment (gc) achieved the highest significant increase in the individual experimental factors. The least significant difference (LSD) test helped clarify the differences between the treatments, reaching 118.29 ($kg.palm^{-1}$) compared to the control treatment of 94.13 ($kg.palm^{-1}$). The difference between the two levels is 24.16 ($kg\ palm^{-1}$), which is higher than the value of (LSD=4.1463) These results indicate that the highest significant increase in individual factors was in the (gc) treatment, as it became clear that directed grazing throughout the season contributed to the accumulation of organic matter rich in nutrients and enzymes, which was reflected in the production of the single palm tree (**22**).The results of the dual treatment interactions (SF - solar sterilization and fungicide, SC - solar sterilization + chemical pesticide, and Sg - solar sterilization and directed grazing with geese) all achieved a significant increase in date palm yield ($kg.palm^{-1}$) at a significance level of ($P \leq 0.05$). The (gc) treatment (directed grazing and fungicide) achieved the highest significant increase in the dual interactions, reaching 118.29 ($kg.palm^{-1}$)

ISSN 2072-3857

compared to the control treatment (94.13 (kg.palm^{-1})). The difference between the two levels was 2.04%, which is higher than the value of (LSD = 4.1463), confirming that directed grazing and the fungicide worked in one direction in supplying the soil with necessary nutrients such as phosphorus, nitrogen, potassium, zinc, calcium, iron, and others to increase growth and production (**9**).The triple intraction(SGF) solarization + directed goose grazing + biofungicide achieved a significant increase in O.M % in the field trial soil at ($P \leq 0.05$). The treatment reached 124.97 (kg.palm^{-1}) compared to the control treatment of 94.13 (kg.palm^{-1}). The difference between the two levels was 30.84 (kg.palm^{-1}), which is higher than the value of (LSD = 4.1463). This confirms that the triple intervention led to a significant increase in palm yield. The reason is attributed to the integration of the effect of the three factors in supplying the soil with different nutrients, improving the chemical, physical, and biological properties of the soil, and eliminating weeds and pathogens (**8**).

Table 5. Effect of weed control treatments on palm yield (kg.palm^{-1})

Treatment	**yield palm kg $^{-1}$**
Sgf	124.97
Sg	117.47
Gc	118.29
Fc	118.07
Sf	113.08
Sc	114.92
Cc	100.03
Ss	98.55
Control	94.13
LSD (0.05)	4.1463

Conclusion

The study results showed that the triple interaction of *Myrotheciumverrucaria* fungus, local goose grazing, and solarization led to a significant increase in date palm production, reaching 24%. Furthermore, the use of environmentally friendly agricultural practices in fertilization and weed control maintains soil health by recycling organic and mineral soil resources and eliminating pathogens. The soil's biotic community can regenerate itself despite extreme high temperatures once environmental stresses are removed.This reflects the importance of the factors in this study in soil and plant health and in the use of sustainable farming methods. This reduces pollution on the one hand and economic costs on the other. We also call for the importance of repeating such field experiments to clarify the role of the interventions of bio-fertilizers, organic fertilizers and environmentally friendly pesticides in soil health and palm yield.

References

1.

2. **Burns, R. G., DeForest, J. L., Marxsen, J., Sinsabaugh, R. L., and Stromberger, M. E. (2013).** Soil enzymes: In a changing environment. Soil Biology and Biochemistry, 47, 156-167.
3. **Gianfreda, L., and Rao, M. A. (2008).** Interactions between xenobiotics and microbial/enzyme activities in soil. Critical Reviews in Environmental Science and Technology, 38(4), 269-310.
4. **Katan, J., and DeVay, J. E. (1991).** Soil Solarization. CRC Press, Boca Raton, FL.
5. **Richardson, A. E., and Simpson, R. J. (2011).** Soil microorganisms mediating phosphorus availability update. Plant Physiology, 156(3), 989-996.
6. **Stapleton, J. J. (2000).** Soil solarization in various agricultural environments. Crop Protection, 19(8-10), 837-841.
7. **Tabatabai, M. A. (1994).** Soil Enzymes. In: Methods of Soil Analysis: Part 2—Microbiological and Biochemical Properties. Soil Science Society of America (SSSA), Madison, WI.
8. **Vencill, W. K., Richburg, J. S., Wilcut, J. W., and Hawf, L. R. (1995).** Effect of halosulfuron on yellow and purple nutsedge (Cyperusesculentus and C. rotundus). Weed Technology, 9(1), 32-35.
9. **Bond, W.; Grundy, A.C. . (2001)** Non Chemical Weed Management in Organic Farming Systems. Weed Res, 41, 383–405.
10. **Bowles . (2014)**Soil enzyme activities, microbial communities, and carbon and nitrogen availability in organic agroecosystems across an intensively-managed agricultural landscape Soil Biol. Biochem.
11. **Boyette, C. D., Hoagland, R. E.,and Weaver, M. A. (2014)**. Bioherbicidal efficacy and selectivity of Myrotheciumverrucaria to control invasive weeds. American Journal of Plant Sciences, 5(26), 3850.

12. **D’Addabbo, T.; Miccolis, V.; Basile, M.; Candido, V.(2009)** Soil Solarization and Sustainable Agriculture. In Sociology, Organic Farming, Climate Change and Soil Science; Springer: Dordrecht, The Netherlands,; pp. 217–274.
13. **Gamliel, A.; Katan, J.** (2012) Soil Solarization: Theory and Practice; APS Press: St. Paul, MN, USA,
14. **Hayat, R., Ali, S., Amara, U., Khalid, R., and Ahmed, I. (2010)**. Soil beneficial bacteria and their role in plant growth promotion: a review. Annals of Microbiology, 60(4), 579-598.
15. **Kear, J. (1963).** The agricultural importance of wild goose droppings. Wildfowl, 14, 6. Retrieved from https://tidsskrift.dk/Wildfowl/article/view/155849
16. **Marenco, R.A. and Lustosa, D.C.(2000)** Soil solarization for weed control in carrot. Pesqui. Agropecu. Bras. , 35, 2025–2032.
17. **Nur H., Zainol I., Nurul S. • Nur A. R.,• Mohd .R., • Maizatul M •, NorliyanaZawawi • Muhamad S. M,.(2026).** Effects of herbicide application on oil palm plantation soil bacterial diversity, function, and co-occurrence networks. World Journal of Microbiology and Biotechnology 42:53.
18. **Pattison AB, McBeath AV, Masters B, Dennis PG (2024).** Direct and indirect effects of Basta®, a glufosinate-based herbicide, on banana plantation soil microbial diversity and function. Appl Soil Ecol 195:10-5.
19. **Pertile M, Sousa RMS, Mendes LW, Antunes JEL, Oliveira LMdS, AraujoFFd, Melo VMM, Araujo ASF (2021)** Response of soil bacterial communities to the application of the herbicides ima¬zethapyr and flumyzin. Eur J Soil Biol 102:32-52.
20. **Peter O, Kang S-M, Imran M, Kim K-U, Lee I-J .(2025).** Functional profiling of novel glufosinate ammonium-tolerant, and secondary metabolite-secreting plant growth-promoting rhizobacteria. Curr Plant Biol.,. 1 0: 15- 3 9
21. **Salem, S. J. and Ali, N. (2017).** A Guide to Chemical Analyses of Soil, Water, Plants and Fertilizers. College of Agriculture - University of Baghdad, Ministry of Higher Education and Scientific Research - Iraq.
22. **Senseman, S. A. (2007).** Herbicide Handbook (9th Edition). Weed Science Society of America (WSSA), Lawrence, KS.
23. **Shuang L. , Jian J. , Huanmin Y. , Peng W. , Quan L. , Yulan H. , Xin Z. , Kuide Y., (2022)** Effect of feeding geese in cornfields on soil bacterial diversity and metabolic function. Applied Soil Ecology ,175.https://doi.org/10.1016/j.apsoil.2022.104448
24. **Stapleton, J. (2000)** Soil solarization for in various agricultural production systems. Crop Prot. , 19, 837–841.

25. **Stapleton, J.J., Molinar, R.H., Lynn-Patterson, K., McFeeters, S.K., Shrestha, A. 2005**, Soil solarization provides weed control for limited-resource and organic growers in warmer climates. Calif. Agric. 59, 84–89.
26. **Steven A., Surendra K. (2019)** Microbial biopesticides for invertebrate pests and their markets in the United States .Journal of Invertebrate Pathology, 165:13-21
27. **Unckless, C. R., and Makarewicz, J. C. (2007).** The impact of migratory Canada Geese (Brantacanadensis) on nutrient loading and water quality. Journal of Great Lakes Research, 33(1), 255-265.
28. **Unckless, C. R., and Makarewicz, J. C. (2007).** The impact of migratory Canada Geese (Brantacanadensis) on nutrient loading and water quality. Journal of Great Lakes Research, 33(1), 255-265.

28.Tabatabai , M. A. 1994. Soil enzymes. In: Weaver RW, Angle JS, Bottomley PS (eds) Methods of soil analysis, part 2. Microbiological and biochemical properties, SSSA book series no. 5. Soil Science Society America, Madison, WI,pp820-823

29.Tabatabai, M. A., and Bremner, J. M. (1969). Use of p-nitrophenyl phosphate for assay of soil phosphatase activity. Soil Biology and Biochemistry, 1(4), 301-307 .

30.Tabatabai, M.A and J.M.Bremner .1972. Assay of urease activity in soils .Soil Biol.Biochem., 4: 479-487.

31- **Richardson, A. E., and Simpson, R. J. (2011).** Soil microorganisms mediating phosphorus availability update. Plant Physiology, 156(3), 989-996.

32-**California Fertilizer Association. (1990).** Western Fertilizer Handbook: Horticulture Edition (1st ed.). Interstate Publishers.

33-**University of Alaska Fairbanks. (2017).** Animal Manure as Fertilizer (Publication No. LPM-00340). Cooperative Extension Service.

34-**Kear, J. (1963).** The agricultural importance of wild goose droppings. Wildfowl, 14(14), 72-77.

35-**Mariash, H. L., Côté, G., and Santo Domingo, J. (2019).** Experimental tests of water chemistry response to ornithological eutrophication: biological implications in Arctic freshwaters. Biogeosciences, 16(24), 4719–4730.

36- **Lu, J., Ryu, H., and Shanks, O. C. (2009).** Microbial diversity and host-specific sequences of Canada goose feces. Applied and Environmental Microbiology, 75(18), 5919-5926.

37-**Unckless, C. R., and Makarewicz, J. C. (2007).** The impact of migratory Canada Geese

(Brantacanadensis) on nutrient loading and water quality. Journal of Great Lakes Research, 33(1), 255-265.

38.Yasin, B., and O., Ali; T. S. Rashid. (2021). Antagonistig activity and plant growth promoting rhizobacteria isolated from forest plant rhizosphereaganstfusariumsolani on thuja seedlings. Iraqi J. of Agricultural Sciences 52(6):1508-1515.

39.Zhang,J.;J. Cook; J.T. Nearing;J. Zhang, and R. Raudonis. (2021). Harnessing the plant microbpome to promote the growth of agricultural crops Microbiol .Res., 245 (12): 1-14.

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