Effect of palm frond compost and phosphate fertilization on vegetative growth characteristics of corn in a gypsum soil

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Abstract.
A field experiment was conducted during the autumn season of 2024, at the research station of the College of Agriculture / Tikrit University, to study the effect of palm frond compost and phosphate fertilization on the growth and yield of yellow corn in gypsum soil. The experiment included two factors, the first is palm frond compost added at levels of 0, 10 and 20 tons ha-1, and the second is phosphate fertilizer added at levels of 0, 40, 80 and 120 kg ha-1. On 20/7/2024, the soil was prepared for cultivation by plowing and smoothing. The experiment was divided into three sectors, each sector containing 12 panels with dimensions of (3x2) m and an area of 6 m^2, with a distance of 1 m between one sector and another and between one panel and another use of randomized complete block design. After that, the drip irrigation system was installed. On July 29, 2024, the seeds were planted in holes at a rate of (2-3) seeds per hole using yellow corn (Zea mays L.) seeds. The crop was harvested on November 20, 2024.
The results showed a significant increase with increasing the compost level from 0 to 20 tons ha^{-1}, as the average increased from (531) ear of corn-1 when no compost was added to (591) ear of corn-1 when using 20 tons ha-1. Phosphorus levels also had a significant effect, as the level of 0 kg ha^{-1} recorded the lowest number of grains, reaching (506) ear of corn-1, while the highest average reached (608) ear of corn-1 at a level of 120 kg ha-1.
A significant effect was also found between compost levels and phosphorus levels on the weight of 500 grains. Al-Khadri. It was noted that increasing the level of compost from 0 to 20 tons ha^{-1} led to a clear increase in the weight of 500 grains, which reached an average of (133.55) g when not added, while it reached (139.91) g when adding 20 tons ha-1. Phosphorus levels also had a significant impact on this trait, with the lowest average reaching (131.74) g at the level of 0 kg ha-1 phosphorus, while the highest weight was achieved when adding 120 kg ha-1 phosphorus.

Keywords. Compost, phosphate fertilizer, gypsum soil, yellow corn

1. Introduction

The use of organic fertilizers by farmers contributes to improving the physical, chemical, and biological properties of soil and increasing the availability of nutrients for plant growth. In general, cow, chicken, goat, and sheep manure are the most commonly used organic fertilizers by Tunisian farmers. However, in the arid regions of southern Tunisia, the use of a mixture of animal manure (especially cow manure) and date palm (Phoenix dactylifera L.) waste, which is converted into organic fertilizer (through composting), is considered a best practice among farmers. The use of date palm manure, produced by mixing dried date palm leaves with cow manure at a ratio of 3:1 and at a moderate dose (30 tons per hectare), significantly increased the fresh biomass production of alfalfa (Medicago sativa L.), which may be linked to improved mineral uptake **[**1**].** Phosphorus (P) is one of the most important macronutrients, along

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with nitrogen, required for plant growth. Adequate phosphorus fertilization is essential for efficient crop production and optimal productivity. However, excessive phosphorus fertilization increases the risk of phosphorus loss to surface and groundwater, with adverse effects on aquatic ecosystems through eutrophication **[**2**].** **[**3**]** found that adding organic waste with triple superphosphate (TSP) and phosphate rock (PR) increased post-harvest phosphorus, and animal waste performed better than composted plant waste. The concept of residual phosphate fertilizers has significant economic benefits, as multiple applications of phosphate fertilizer can be applied at once, sufficient for several seasons. This reduces labor, machinery, and storage costs, and can also reduce farm losses due to price fluctuations. Several batches are made at once when fertilizer prices drop, eliminating the problem of high prices [4].Maize is a member of the grass family and is considered one of the most important crops. It comes after wheat and rice in importance due to its multiple use[5]. Gypsum soils are defined as soils that contain a gypsum or petrogypsum horizon, the upper limit of which ranges from (100) to (125) cm from the soil surface . Gypsum soils are both a problem and a mystery. Gypsum soils (with a high percentage of gypsum) are found in arid and semi-arid regions with low population density, which affects the physical and chemical properties of the soil.

Given the paucity of studies on the effect of palm frond compost and phosphate fertilizer on the growth and yield of maize in gypsum soils, the study aimed to:

1- Study the effect of palm frond compost and phosphate fertilizer on the yield and components of maize.

2- Determine the level and type of plant residues that achieve the highest response.

2- Materials and Methods:

2-1 Experiment Site

The field experiment was carried out at the research station of the Department of Soil Sciences and Water Resources / Fields of the College of Agriculture / Tikrit University at latitude N 34.4057 and longitude E 43.3856 to study the effect of palm frond compost and phosphate fertilization on the growth and yield of yellow corn in gypsum soils for the autumn season 2024 AD.

2-2 Soil Analysis

Soil samples were taken randomly from the field planting, at a depth of (0-30) cm, for the purpose of conducting laboratory analyses to determine the physical and chemical properties of the soil. The results were as shown in Table. (1).

Table. (1) Physical and chemical properties of the soil before planting

Adjective	**Unit**	**Value**
sand	Soil 1 kg	366
Silt		282
Clay		352
Texture	clay mixture	

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Bulk Density	Mega gram kg-1	1.47
PH		7.61
Electrical Conductivity	dsm-1	3.81
Gypsum CaSO4	Soil 1 kg	48.1
Lime CaCO3		265
Organic Matter	%	0.86
Available Nitrogen	Soil amalgam kg-1	18
Available Phosphorus		7.5
Available Potassium		123

2-3 Soil Preparation for Cultivation

On 20/7/2024, the soil was prepared for cultivation by plowing and smoothing. The experiment was divided into three sectors, each containing 12 panels (3x2) m in size and an area of 6 m2. The distance between each sector and each panel was 1 m. Then, a drip irrigation system was installed. On 29/7/2024, the grains were planted in holes at a rate of (2-3) seeds per hole using yellow corn (Zea mays L.) seeds of the Serbian Chloria variety purchased from local markets. There was a distance of (25) cm between holes and (75) cm between rows, so that the number of rows became (4) and (8) plants in each row. After (11) days of planting, the patching and thinning process was carried out, so that there was one plant in each hole.

2-4 Experimental Design and Preparation

The experiment was implemented according to a randomized complete block design (RCBD) with three replicates, each replicate containing (12) treatments, and the number of experimental units was (36) randomly distributed units.

2-5 How to Prepare Palm Frond Compost

1. Take 1 ton of palm fronds and crush them with a dedicated crushing machine, making them (2-5) cm thick. Moisten the crushed material for (7) days until the color changes to brown and the moisture content reaches (60-70)%.

2. After moisturizing, add half the amount of poultry manure (50) kg out of (100) kg, along with (10) kg of urea, (10) kg of superphosphate, and (50) kg of clayey soil. Mix the added ingredients well with the

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crushed fronds and form a bundle (mound) 1.5-2 m high and (2-2.5) m wide.
3. After that, (7-9) turns are made between one turn and another, from (7-10) days, and the remaining amount of supplements is added as follows:
• The remaining (10) kg of urea is added in three batches during the first, second, and third stirs.

2-6 Phosphorus and Compost Levels
The experiment included the following treatments:
1. Phosphorus at four levels (0, 40, 80, and 120) kg P h^{-1}

2-7 Fertilization
2-7-1 Organic Fertilization
Organic fertilizer (palm frond compost) was added by making a 10 cm deep furrow, distributing the fertilizer in the furrow, and covering it with soil. The compost was prepared in the Karbala site for organic fertilizer preparation and mushroom cultivation.

2 - 72 - Chemical Fertilization
The fertilizer recommendation was 360 kg N h^{-1}, applied in three batches: one before planting and two after planting.
200 kg k h^{-1} was applied in two batches after planting [6]**.**

2-8 Weed and Insect Control
Weeding and servicing were carried out manually for all transactions, and control of the corn stalk borer was carried out using the granular diazinon pesticide (20-35) days after germination (Al-Barzanji, 2006). The servicing operations, including weed removal and irrigation, continued until the end of the season on 11/20/2024.

2-9 Yield Characteristics
2-9-1 Number of Grains per Ear
The average number of rows divided by the number of grains per row for five ears from

• The remaining (50) kg of poultry manure is added during the third stir.
• The remaining stirs are mixed with spraying to compensate for the missing amount, ensuring that the humidity does not exceed (60-70)%.
The final product is dark brown to black in color and has a smell similar to that of mushrooms or sprayed soil.

2. Compost at three levels (0, 10, and 20) tons h^{-1}

each experimental unit, drawn from the mid-rows, randomly [7].

2-9-2 Weight of 500 grains (g)
500 grains were manually counted from each treatment and randomly weighed using a sensitive electronic balance.

2-9-3 Grain yield of yellow corn (kg h^{-1})
Grain yield is calculated by multiplying the grain yield per plant by the plant density based on moisture content (15.5%) .

2-9-4 Protein Concentration (%)
The percentage of protein can be determined by the equation, as stated in (A.O.A.C, 1975): Protein concentration in grains (%) = Nitrogen concentration in grains (%) × 6.25.

3- Results and Discussion
3- Effect of palm frond compost levels, phosphorus levels, and their interaction on the yield and components of yellow corn in gypsum soils.

3-1 Number of grains in the ear (ear-1 grain)
The results of Table (2) indicated a clear significant effect of both palm frond compost levels and phosphorus levels, as well as their interaction, on the number of grains per ear (ear/corn) of yellow corn. Organic fertilization with compost showed an

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increase in the number of grains, with the average rising from (531) ear/corn when no compost was added to (591) ear/corn when 20 tons ha/corn was used. This indicates that compost contributed to improving soil fertility and providing the necessary nutrients during the flowering and fertilization stages, which was reflected in the number of grains. These results are consistent with [8]. The results also showed that the number of grains increased with increasing phosphorus levels, with the lowest average recorded at 0 kg ha^{-1}, reaching (506) ear grains^{-1}, while the highest average reached (608) ear grains^{-1} at the 120 kg ha^{-1} level, reflecting the vital role of phosphorus in promoting flowering and grain formation. These results are consistent with [**9**] . As for the interaction between compost and phosphorus, the treatment of 20 tons of compost + 120 kg of phosphorus had the highest effect, reaching (629) ear of corn^{-1} grains, and did not differ significantly from the treatment of 20 tons of compost + 80 kg of phosphorus (612) ear of corn^{-1} grains, while the comparison treatment (0 tons of compost + 0 kg of phosphorus) recorded the lowest number of grains, reaching (477) ear of corn^{-1} grains.

Table 2. Effect of palm frond compost level, phosphorus level and their interaction on the number of grains in the ear of yellow corn (ear-1 grain).

Phosphorus level (kg h-1) / Compost level (tons ha-1)	0	40	80	120	Average compost level
0 (without addition)	477 i	512 g	549 f	586 cd	531 C
10	499 h	567 e	590 c	608 b	566 B
20	538 f	583 cd	612 ab	629 a	59 1A
Average phosphorus level	50 6D	554 C	58 4B	60 8A	
Means with similar letters are not significantly different according to Duncan's test at a 5% probability level.					

3-2 500-seed weight (g)

The results of Table (3) indicated a significant effect of palm frond compost levels, phosphorus levels, and their interaction on the 500-seed weight (g) of yellow corn. It was observed that increasing the compost level from 0 to 20 tons ha^{-1} resulted in a significant increase in the 500-seed weight, with an average of 133.55 g when no compost was added, while it reached 139.91 g when 20 tons ha^{-1} of compost was added. This indicates that compost contributed to improving growth characteristics and yield by enhancing the physical and chemical properties of the soil and increasing nutrient availability. These results are consistent with [**10**]. Phosphorus levels also had a significant impact on this trait, as the level of 0 kg ha^{-1} recorded the lowest average of (131.74) g, and gradually increased to reach (140.21) g at the level of 120 kg ha^{-1}. This is attributed to the important role of phosphorus in grain formation, carbohydrate transport, and improving grain filling. These results are consistent with [**1**1]. The interaction between the two study factors showed the best results in the treatment of 20 tons of

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compost + 120 kg of phosphorus, where the weight of 500 grains reached (142.57) g, followed by the treatment of 20 tons of compost + 80 kg of phosphorus (141.07) g, while the comparison treatment (0 tons of compost + 0 kg of phosphorus) recorded the lowest value of (127.56) g. These results reflect the complementary importance of organic and mineral fertilization in improving grain quality and increasing its weight, which contributes to raising total production.

Table 3. Effect of palm frond compost level, phosphorus level and their interaction on the 500-grain weight content of yellow corn (g)

Phosphorus level (kg h-1) / Compost level (tons ha-1)	0	40	80	120	Average compost level
0 (without addition)	127.56 f	132.11 de	136.43 c	138.09 bc	133.55 C
10	131.23 e	135.00 cd	138.06 bc	139.97 ab	136.07 B
20	136.42 c	139.59 ab	141.07 ab	142.57 a	139.91 A
Average phosphorus level	131.74 C	135.57 B	138.52 A	140.21 A	
Means with similar letters are not significantly different according to Duncan's test at a 5% probability level.					

3-3 Total Grain Yield (kg ha-1)

The results of Table (4) showed a clear significant effect of palm frond compost levels, phosphorus levels, and their interaction on the grain yield (kg ha-1) of yellow corn. The yield increased with increasing the level of compost from 0 to 20 tons ha^{-1}, where the average yield reached (7763) kg ha^{-1} when not added, and rose to (9016) kg ha^{-1} at the highest level of compost (20 tons ha^{-1}). The reason for this may be attributed to the role of organic fertilizer rich in nutrients and its positive effect in improving the physical and chemical properties of the soil, which led to an increase in its fertility and an increase in the availability of nutrients (N, P and K) in the soil, and then an increase in the amounts absorbed from it and an increase in the grain yield. These results are consistent with what was indicated [**1**2], that the addition of organic fertilizer led to a significant increase in grain production for the yellow corn crop. Phosphorus levels also had a significant effect, as the 0 kg ha^{-1} level recorded the lowest yield of (7234) kg ha^{-1}, while the 120 kg ha^{-1} level gave the highest yield of (9289) kg ha^{-1}. This is attributed to the role of phosphorus in stimulating root growth, increasing the efficiency of nutrient absorption, and improving plant metabolic processes. These results were consistent with, and also with Onasanya at al. (2009), who found that adding phosphorus at an average of (20, 40, and 60) kg P ha-1 gave maize grain yields of (4.59, 5.12, and 5.11) tons ha-1, while the control treatment gave a lower yield of (3.08) tons ha-1. As for the interaction between the compost and phosphorus factors, it was shown that the treatment of 20 tons of compost + 120 kg of phosphorus recorded the highest yield of (9810) kg of phosphorus, while the comparison treatment (0 tons of compost + 0 kg of phosphorus) recorded the lowest yield of (6711) kg of phosphorus.

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Table 4. Effect of palm frond compost level, phosphorus level and their interaction on grain yield of yellow corn (kg ha-1)

Phosphorus level (kg h-1) / Compost level (tons ha-1)	0	40	80	120	Average Compost level
0 (without addition)	6711 g	7401 f	8100 d	8839 c	7763 c
10	7003 f	8289 d	8921 bc	9219 b	8358 b
20	7988 de	8809 c	9456 ab	9810 a	9016 a
Average phosphorus level	7234 d	8166 c	8826 b	9289 a	
Means with similar letters are not significantly different according to Duncan's test at a 5% probability level.					

3-4 Protein Concentration in Grains (%)

Table (5) indicates that protein concentration in yellow corn grains was significantly affected by palm frond compost levels, phosphorus levels, and the interaction between them.

When considering phosphorus levels, the highest level (120 kg ha^{-1}) had the highest protein concentration, reaching 14.42%, significantly superior to the lower levels (0, 40, and 80 kg ha^{-1}), which recorded averages of 11.73%, 12.83%, and 13.58%, respectively. The increased protein content of grains with increased phosphorus levels may be attributed to the efficiency of phosphorus in increasing the root system and thus increasing nitrogen uptake, which is reflected in the grain's protein content (Table 20). Phosphorus also plays a role in increasing the plant's efficiency in utilizing nitrogen, thus increasing its compounds, which are involved in protein formation, thus increasing its percentage in grains. This is consistent with [**1**3] . who found that adding phosphate fertilizer increased the protein concentration of wheat grains. Regarding the effect of compost, the results showed that increasing its rate had a clear positive effect, as the average protein concentration at the 20 t/ha^{1} level reached approximately 14.25%, while it reached 13.42% and 12.17% at the 10 t/ha^{1} and no added fertilizer levels, respectively. This is attributed to compost improving soil properties and increasing the availability of nutrients, especially nitrogen, which is essential for protein formation. These results are consistent with (. In the interaction between the two factors, the treatment (20 tons of compost + 120 kg of phosphorus h^{-1}) recorded the highest protein concentration value, reaching 15.25%, significantly superior to the other treatments, reflecting the complementary effect of organic and mineral fertilization in increasing the nutritional value of the crop.

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Table 5. Effect of palm frond compost level, phosphorus level and their interaction on protein concentration in yellow corn grains (%)

Phosphorus level (kg h-1) / Compost level (tons ha-1)	0	40	80	120	Average compost level
0 (without addition)	10.31h	11.88g	12.81ef	13.69cd	12.17C
10	11.75g	12.56f	13.38d	14.31b	13.42B
20	13.13de	14.06bc	14.56b	15.25 a	14.25A
Average phosphorus level	11.73D	12.83C	13.58B	14.42A	
Means with similar letters are not significantly different according to Duncan's test at a 5% probability level.					

Conclusions

1. Palm frond compost had a clear positive effect on improving the vegetative growth characteristics of maize, contributing to increased dry weight, absolute growth rate, and nitrogen and phosphorus concentrations, particularly at levels of 20 tons ha-1.
2. Phosphate fertilization showed significant increases in plant growth and nitrogen and phosphorus uptake, particularly at levels of 120 kg ha-1.
3. A significant interaction was observed between compost and phosphorus, with treatments combining the highest levels of both factors (20 tons compost and 120 kg phosphorus) achieving significant improvements in the studied traits.
4. Improved nitrogen and phosphorus uptake efficiency.
5. Compost reduced phosphorus fixation in gypsum soils, leading to increased phosphorus availability and improved maize growth.

Recommendations

1. We recommend using 20 tons per hectare of palm frond compost as part of the organic fertilization program for yellow corn in gypsum soils.
2. Adopt a phosphate fertilizer application level of 120 kg of phosphorus per hectare.
3. Adopt integrated fertilization (organic + mineral) as a sustainable approach to improving soil fertility and reducing reliance on chemical fertilizers alone.
4. Encourage farmers to recycle palm frond waste and convert it into compost, which contributes to agricultural waste management and improved productivity.
5. Conduct future studies on various crops to evaluate the effectiveness of palm frond compost and phosphorus in improving soil properties and production in soils with different gypsum content.

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