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Research Article

Effect of Soil Amendments and Antitranspirants on the Growth and Yield of Peanut (*Arachis hypogaea* L.)

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Abstract | This study was conducted to evaluate the effect of soil amendments and anti-transpirants on the growth and yield of peanut (*Arachis hypogaea* L.) under the climatic conditions of Wasit Governorate, Iraq, during the 2024 growing season. The experiment was arranged in a split-split plot design within a randomized complete block design (RCBD), involving soil amendments (biochar, peat moss, perlite, and no amendment) and anti-transpirants (okra extract, potassium silicate, and no spray). The results showed that the biochar and okra extract treatment significantly outperformed all other treatments in all measured growth and yield parameters, recording the highest leaf area (13493 cm^2), chlorophyll content (4.77 mg/g), peanut shoot dry weight (0.218 Kg/plant) and pod yield (596.4 kg/donum). This improvement is attributed to biochar's ability to enhance soil properties and increase water and nutrient availability, along with okra extract's role in reducing water loss through stomata and maintaining plant water balance. The study concludes that integrating organic soil amendments with natural anti-transpirants is an effective strategy to improve peanut growth and productivity, especially under conditions of water stress.

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Introduction

Peanut (*Arachis hypogaea* L.) is an important oilseed legume crop with significant economic value. Its seeds contain up to 50% oil and globally, peanut ranks fourth in oil production after soybean and fifth in protein production after soybean and maize. In addition to its nutritional and industrial value, this crop contributes to improving soil fertility—especially in sandy, low-productivity soils—by adding organic matter and fixing nitrogen via symbiotic rhizobial bacteria in its roots (AL-Hilfy and Al-Muger, 2016; Mohammed *et al*., 2025; Saood *et al*., 2025). However, expansion of peanut cultivation in Iraq remains limited due to several agronomic challenges. These include the crop's sensitivity to soil texture, the need for precise irrigation management, and the difficulty of pod penetration and extraction

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in fine-textured soils, which complicates harvesting and increases the risk of fungal diseases. In the face of these challenges, there is a growing need to adopt modern agricultural techniques that conserve water and improve production efficiency. Transpiration is a vital physiological process in plants, contributing to water balance regulation, nutrient transport, and cooling of plant tissues (Raveendran *et al*., 2018; Mohammed *et al*., 2025). Soil physical properties are also crucial for crop success; many studies have highlighted the importance of using soil amendments to improve soil structure, aeration, and water-holding capacity, thereby enhancing plant growth and productivity (Aslan *et al*., 2018; Najem, 2021; Najem *et al*., 2024). Nevertheless, excessive water loss via transpiration—especially in arid regions under limited irrigation—disrupts the plant's water balance and consequently reduces growth and yield (Lamiter, 2020). To mitigate these losses, various techniques have been developed, foremost among them anti-transpirants, which are substances applied to foliage to decrease water loss either by forming a protective film that reduces evaporation or by regulating stomatal opening and closing (Sadoon *et al*., 2022; Wang *et al*., 2023; Ali *et al*., 2024). These compounds have proven effective in improving water use efficiency in several crops; however, studies on their effects in peanut remain limited, particularly under Iraqi environmental conditions.

In light of the above, the present study aims to evaluate the effect of soil amendments and anti-transpirants on the growth and yield of peanut under the climatic conditions of Wasit Governorate. The goal is to identify integrated agronomic practices that can enhance peanut performance under water-stress conditions.

Materials and Methods

Experiment site

A field experiment was conducted in the 2024 growing season at the Agricultural Research Station of the Wasit Agriculture Directorate in the Al-Kardhiya area (45°54′31.7″ E, 32°32′15.21″ N; 25 m above sea level). The soil was classified as silty clay loam in the top layer (0–10 cm) and clay loam in the 10–20 cm and 20–30 cm layers. The experiment was arranged in a split-split plot layout within a randomized complete block design (RCBD) with three replications. The treatments consisted of four soil amendment levels (biochar, peat moss, perlite, and no addition) assigned to main plots, and three antitranspirant treatments (okra extract, potassium silicate, and no antitranspirant) assigned to sub-plots. A total of 4 × 3 × 3 = 36 experimental units were used. Each experimental plot measured 3 × 3 m; four ridges (rows) were prepared per plot with 0.75 m between ridges and 0.30 m between plants, giving 10 plants per ridge (40 plants per plot). Peanut seeds (local variety from Diyala Province) were sown on April 26, 2024, and harvesting was carried out on October 30, 2024. Results were analyzed statistically using the Least Significant Difference (LSD) test at the 0.05 probability level.

Application of soil amendments and antitranspirants

After land preparation with perpendicular plowing and layout of equal-sized plots on ridges, the soil amendments (biochar, peat moss, and perlite) were applied at 127 g per plant at the time of planting. The antitranspirants—okra extract and potassium silicate (commercial name "Orsilic")—were then foliar-sprayed in three applications: the first on May 20, 2024, the second on July 1, 2024, and the third on August 1, 2024.

Measured traits

Leaf area (cm^2)

Leaf area was measured on five sample plants from each experimental unit. For each plant, the maximum length (L) and width (W) of fully expanded leaves were recorded, and the leaf area was calculated using the formula for an ellipse (for near-oval leaflets) according to Li *et al*. (2018): A= L/2×W/2× π , where *A* is the calculated leaf area (cm^2), *L* is leaf length (cm), *W* is leaf width (cm), and π is 3.14. The actual leaf area was obtained by multiplying the calculated area by 1.2 (a correction factor for peanut), and the total leaf area per plant was then determined by multiplying the adjusted area by the number of leaves per plant.

Chlorophyll content (mg/g)

Leaf chlorophyll content was measured on five plants from each plot. Samples of fresh leaves were analyzed using a spectrophotometer, following the method described by Arnon (1949). Chlorophyll content is expressed as mg of chlorophyll per g of fresh leaf tissue.

Dry weight (g)

The shoot dry weight of five plants from each experimental unit was determined. Sample plants were first air-dried, then oven-dried at 65 °C for 48 hours (A. O. A. C,1975) until a constant weight was achieved. Dry weight is expressed in grams per plant.

Total Yield (kg per donum)

Total yield was calculated from the total weight of peanut pods harvested per experimental plot (3 × 3 m area), extrapolated to a per-donum basis (1 donum = 2500 m^2). Yield is expressed as kilograms of pods per donum of land.

Results and Discussion

Leaf area (cm^2)

Data shown in Table 1 clearly demonstrated that the treatment with biochar combined with okra extract recorded the highest mean leaf area (13,493 cm^2), followed by biochar with potassium silicate (11,001 cm^2). This finding highlights the vital role of biochar in enhancing the vegetative growth of peanut (*Arachis hypogaea L.*). Such an effect can be attributed to the ability of biochar to improve the physical and chemical properties of the soil, increase its water-holding capacity, and enhance nutrient availability. These improvements promote physiological processes such as photosynthesis, leading to a substantial expansion of leaf area. These results are consistent with the findings of Kiziloglu *et al.* (2023), who reported that biochar application in peanut crops significantly increased leaf area, nutrient uptake efficiency, and chlorophyll content, particularly under saline soil conditions, thereby contributing positively to vegetative growth parameters. The peat moss treatment with okra extract (10,642 cm^2) also showed a strong performance, which may be attributed to its effectiveness in improving aeration and water retention, thereby stimulating vegetative development. These results align with the findings of Lamichhane (2023), who demonstrated that mixing peat moss with biochar enhanced growth traits, including leaf area, in various ornamental and vegetable plants, suggesting a generally positive influence on plant growth.

In contrast, perlite combined with okra extract recorded a relatively lower mean leaf area (7,773 cm^2), though it still outperformed the control treatment. This effect can be explained by the role of perlite in improving root aeration and drainage of excess water. Kang *et al.* (2021) similarly reported that the use of perlite in soybean cultivation improved leaf area development due to better aeration and reduced flooding stress. With regard to antitranspirants, okra extract achieved the highest mean leaf area (9,300 cm^2), followed by potassium silicate (8,493 cm^2), whereas the untreated plants recorded the lowest values (6,192 cm^2). This indicates that okra extract, owing to its content of phytochemicals such as phenolics and saponins, plays a role in reducing water loss through transpiration and enhancing the plant's water status, which in turn promotes vegetative growth. These findings are supported by the study of Agboola and Omueti (2022), which showed that the use of okra extract and potassium silicate as antitranspirants in peanut cultivation significantly increased leaf area compared to the control, due to improved water absorption efficiency and reduced moisture loss.

Table 1: *Effect of soil amendments and antitranspirants on peanut leaf area (cm^2).*

Soil amendment	Antitranspirants			Mean amendment	
	Okra Extract	Potassium Silicate	No Anti-transpirants		
Biochar	13493	11001	8507	11000	
Peat moss	10642	9645	7638	9308	
Perlite	7773	7480	6269	7174	
No amendment	5291	5847	2354	4497	
LSD 0.05	1133			LSD 0.05	843
Mean anti-transpirants	9300	8493	6192		
LSD 0.05	546				

On the other hand, the control treatment (without soil amendments or antitranspirants) recorded the lowest leaf area values (2,354 cm^2), reflecting the limited vegetative growth of plants in the absence of organic amendments or biostimulants. This outcome can be attributed to the relative degradation of the soil's physical and biological properties, leading to poor aeration and restricted uptake of water and nutrients, thereby constraining leaf development and reducing overall leaf area. Similar findings were reported by Hala *et al.* (2025) in common beans (*Phaseolus vulgaris* - Borlotti beans), where untreated control plants exhibited significantly lower leaf area compared to fertilized or microbially stimulated treatments. The researchers attributed this to the lack of soil biological activity and organic matter, which in turn limited photosynthetic efficiency and vegetative growth.

Table 2: *Effect of soil amendments and antitranspirants on leaf chlorophyll content (mg/g).*

Soil Amendments	Antitranspirants			Mean amendments	
	Okra extract	Potassium silicate	No anti-transpirants		
Biochar	4.77	4.60	3.90	4.42	
Peat moss	4.60	4.43	3.90	4.31	
Perlite	3.80	3.63	3.33	3.59	
No amendments	3.33	3.07	2.60	3.00	
LSD 0.05	0.127			LSD 0.05	0.077
Mean anti-transpirants	4.125	3.933	3.433		
LSD 0.05	0.025				

Chlorophyll content (mg/g)

Based on the analysis of Table 2 regarding chlorophyll content (mg/g), it is clear that there were significant differences among the treatments, which reflects the varying effects of soil amendments and antitranspirants in enhancing the physiological efficiency of the peanut crop, especially in terms of chlorophyll content in the leaves. The treatment of biochar with okra extract recorded the highest mean chlorophyll content (4.77 mg/g), followed by biochar with potassium silicate (4.60 mg/g), and then peat moss with okra extract. These results reflect the positive effect of biochar in enhancing photosynthetic efficiency through improving the physical and chemical properties of the soil, especially under water stress conditions. These findings were supported by the study of Kang *et al.* (2021), which showed that the addition of biochar or perlite contributed to improving chlorophyll content in soybean (*Glycine max*) under water stress, as a result of improving moisture retention and enhancing nutrient uptake in the root zone.

As for peat moss treatment, it also showed high effectiveness, recording (4.60 mg/g) with okra extract. This is attributed to the ability of peat moss to improve soil aeration and retain water and nutrients, which supports chlorophyll synthesis in legume plants. These results agree with the findings of Lamichhane (2023), who reported in a study on ornamental and legume plants that the use of peat moss increases vegetative growth efficiency and chlorophyll content due to its richness in organic matter and its role in modifying the properties of the growth medium. With regard to perlite, although it recorded relatively lower values (3.80 mg/g as the highest mean), its use with okra extract was better than the control treatment, which reflects its role in improving aeration and alleviating stress. This was also confirmed by the study of Kang *et al.* (2021), where perlite was included in the composition of a growth medium that led to a relative improvement in chlorophyll content in soybean under water stress conditions. As for the antitranspirant treatments, the results showed a clear superiority of okra extract (4.125 mg/g) over both potassium silicate (3.933 mg/g) and the treatment without antitranspirant (3.433 mg/g). This superiority is attributed to the content of okra extract in active compounds such as phenolics and saponins, which play a dual role: acting as natural antitranspirants by reducing stomatal opening, and at the same time stimulating physiological activity by improving nutrient absorption, which is reflected in leaf growth and expansion. These results were supported by the study of Hygienus (2025), which was conducted on okra (*Abelmoschus esculentus*) under water stress, where the results showed that the use of plant extracts such as okra infusion contributed to a significant increase in total chlorophyll content, as a result of improved water and nutrient absorption and the activation of vital processes inside the plant.

The study also showed that okra extract, as a natural plant extract, possesses antitranspirant properties that help reduce the effects of environmental stress and maintain the biological activity of the plant. The control treatment (without amendment and without antitranspirant) showed the lowest mean value (2.60 mg/g), which reflects the effect of the absence of organic amendments and biostimulants on the physiological efficiency of the plant, leading to a decrease in chlorophyll content under water stress. These results agree with those reported by Kang *et al.* (2021), when comparing untreated plants in soils poor in organic matter. The results show that the use of biochar, peat moss, okra extract, and potassium silicate all contributed to enhancing chlorophyll content, while plants in the control treatment suffered from a clear decrease in this important trait, highlighting the importance of organic amendments and antitranspirants in supporting the physiological functions of the peanut crop under local conditions.

Table 3: *Effect of soil amendments and antitranspirants on peanut shoot dry weight (Kg per plant).*

Soil amendments	Antitranspirants			Mean amendments	
	Okra extract	Potassium silicate	No anti-transpirants		
Biochar	0.218	0.175	0.180	0.191	
Peat moss	0.171	0.140	0.137	0.149	
Perlite	0.127	0.119	0.121	0.122	
No amendments	0.131	0.123	0.080	0.111	
LSD 0.05	0.029			LSD 0.05	0.023
Mean amendments	0.162	0.139	0.129		
LSD 0.05	0.011				

Dry weight (Kg)

The results shown Table 3 showed significant differences in dry weight, with the treatment of biochar with okra extract recording the highest value (0.218 kg), followed by biochar with potassium silicate (0.175 kg). This reflects the positive effect of biochar in improving the structural growth of plants. This effect is attributed to its superior ability to enhance the physical and chemical properties of the soil and increase the efficiency of nutrient uptake. These results are consistent with the study of Kang *et al.* (2021), which showed that the use of biochar led to a significant increase in dry weight in soybean plants. Peat moss with okra extract also contributed to improving the dry weight of plants (0.171 kg), as a result of peat moss improving soil aeration and providing balanced moisture in the root zone, which stimulates the formation of greater biomass. This agrees with the findings of MH *et al.* (2024), who reported that the incorporation of peat moss into the growth medium improved the dry mass of various legume crops. As for perlite, it recorded relatively lower levels (highest mean 0.127 kg), which is consistent with the results of Lamichhane (2023), who explained that excessive use of perlite may reduce water cohesion in the growth medium, which negatively affects dry weight, particularly in advanced growth stages. Regarding the effect of antitranspirants, okra extract treatment (mean 0.162 kg) was superior to the other treatments, due to the presence of phenolic compounds and saponins that reduce water loss through stomata, thereby maintaining water balance and allowing the plant to direct its energy toward forming a higher dry mass. This mechanism was confirmed by Hygienus (2025) in his experiment on legumes, where he pointed to the role of okra extract in reducing water stress and improving biomass growth indicators. The treatment without amendments or antitranspirants recorded the lowest value (0.080 kg), which indicates that the absence of organic materials and plant-based inhibitors weakens the plant's ability to build dry tissues, especially under stressful environmental conditions. This was also reported by Vasilyeva *et al.* (2024), who showed that untreated plants exhibited a marked weakness in all dry growth indicators.

Table 4: *Effect of soil amendments and antitranspirants on total peanut yield (kg per donum).*

Soil amendments	Antitranspirants			Mean amendments	
	Okra extract	Potassium silicate	No anti-transpirants		
Biochar	596.4	275.6	251.7	374.6	
Peat moss	267.7	283.2	217.3	256.0	
Perlite	186.8	181.6	133.7	167.4	
No amendments	140.3	164.7	126.0	143.6	
LSD 0.05	89.3			LSD 0.05	80.9
Mean anti-transpirants	297.8	226.3	182.2		
LSD 0.05	32.4				

Total yield (kg/donum)

The results in Table 4 showed that the treatment of (biochar and okra extract) recorded the highest mean total yield (596.4 kg/dunum). This is attributed to the integrated effect of these two factors in improving aeration, reducing water loss, and increasing the availability of nutrients, which positively reflects on photosynthesis and dry matter accumulation. These results were confirmed by Ding *et al.* (2021), who reported that the use of biochar in peanut cultivation improves soil structure and increases nutrient uptake efficiency, thereby enhancing productivity under water stress conditions. The treatment of (peat moss + okra extract) recorded (267.7 kg/dunum), which is due to the ability of peat moss to retain moisture for longer periods and improve soil organic matter content, properties that are very important in peanut cultivation. This finding was supported by Lamichhane *et al.* (2023), who showed that peat moss contributes to improving soil structure and root distribution, leading to enhanced yield in legumes. Meanwhile, the treatment of (perlite + okra extract) also showed noticeable improvement, recording

(186.8 kg/dunum). This is linked to the ability of perlite to improve water drainage and root aeration. These results agree with Kang *et al.* (2021), who indicated that the use of perlite in the growth medium of peanut helped increase total yield by improving water and nutrient dynamics in the rhizosphere. On the other hand, the treatment of peat moss + potassium silicate (283.2 kg/dunum) ranked second after biochar with okra extract in increasing yield, which highlights the combined effectiveness of these treatments. It is well known that potassium silicate improves plant resistance to stress and stimulates the growth of reproductive organs. This was documented by Kaya *et al.* (2020) in their study on peanut, where silicates contributed to improving growth quality under challenging soil conditions. The treatment without amendments and without antitranspirant recorded the lowest total yield (126.0 kg/dunum), which confirms the weak performance of soil in the absence of organic or physiological treatments. This finding agrees with the study of Olaoye and Aliyu (2021), who indicated that the absence of organic amendments and plant-based inhibitors leads to a significant decline in peanut productivity, especially under non-optimal environmental conditions. As for the effect of antitranspirants, okra extract showed clear superiority with a general mean of (297.8 kg/dunum), surpassing potassium silicate (226.3 kg/dunum) and the treatment without antitranspirant (182.2 kg/dunum). This indicates that the active compounds such as phenolics and saponins present in okra extract contribute to improving the plant's water status and reducing water loss, thereby enhancing photosynthetic efficiency and growth. These findings were supported by Mwanamwenge *et al.* (2024), who reported similar results when using plant extracts on peanut crops, which led to an increase in total crop yield.

Conclusions

In this study concludes that integrating organic soil amendments with natural anti-transpirants is an effective strategy to improve peanut growth and productivity, especially under conditions of water stress.

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Novelty Statement

This study is the first to evaluate the combined effects of organic soil amendments and natural okra-extract antitranspirants on peanut performance under the climatic conditions of Wasit, Iraq. The integrated approach demonstrated superior improvements in growth, physiology, and yield, offering an effective, sustainable strategy for peanut production under water-stress conditions.

Author's Contibution

This work was completed collaboratively by all authors. R. M. A., J. N. A. and R. J. M. each contributed to formulating the research idea and solving the research problem. R. M. A. and J. N. A: participated in conducting the experiment, interpreting the results, and writing the paper. R. J. M. interpreted the results and reviewed the paper.

Generative AI and AI-assisted technology statement

The authors declare that no generative AI and AI assisted technology was used in the creation of this manuscript.

Conflict of Interest

The authors declare no conflict of interest.

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