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Assessment of soil pollution in Wasit Governorate by brick factories in Al-Hay District

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Abstract:

A field study was conducted during the spring season of 2024 to evaluate the effect of soil amendments and transpiration inhibitors on the water requirements of the peanut crop (*Arachis hypogaea* L.) under surface drip irrigation conditions in Wasit Governorate, adopting the calculation of actual water consumption based on 50% depletion of available water. The study included four types of soil amendments (biochar, peat moss, perlite, and a control without amendment) and three types of transpiration inhibitors (okra extract, potassium silicate, and a control without inhibitor). The results showed the superiority of the biochar treatment combined with okra extract in reducing actual water consumption, recording the lowest value of 353.6 mm compared with the control treatment, which recorded 712.6 mm. This was accompanied by a clear reduction in the number of irrigations and the amount of irrigation water at all growth stages. This treatment also led to a significant decrease in crop coefficient (Kc) values, reflecting improved water use efficiency and reduced water loss without negatively affecting plant growth. Overall, the results indicate that soil amendments, particularly biochar, effectively contributed to reducing water requirements, while okra extract outperformed potassium silicate in limiting water loss through transpiration. The interaction between soil amendments and transpiration inhibitors proved to be more effective than using either alone, achieving water savings of up to about 50% without harming plant growth. These findings highlight the importance of adopting integrated water management techniques to enhance water use efficiency and support the sustainability of peanut cultivation in water-scarce environments.

Keywords: Peanut, soil amendments, transpiration inhibitors, actual water consumption, crop coefficient, drip irrigation.

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تأثير محسنات التربة ومثبطات النتح على الاحتياجات المائية لمحصول فستق الحقل المزروع تحت نظام الري بالتنقيط
السطحي في محافظة واسط .

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الخلاصة

أجريت دراسة حقلية خلال الموسم الربيعي لسنة 2024 بهدف تقييم تأثير محسنات التربة ومثبطات النتج على الاحتياجات المائية لمحصول فستق الحقل *Arachis hypogaea L.* تحت ظروف الري بالتنقيط السطحي في محافظة واسط، مع اعتماد حساب الاستهلاك المائي الفعلي حسب استنزاف 50% من الماء الجاهز. تضمنت الدراسة أربعة أنواع من محسنات التربة (فحم حيوي، بتموس، برلايت، ومعاملة بدون محسن) وثلاثة أنواع من مثبطات النتج (منقوع باميا، أورسليك، ومعاملة بدون مثبط). أظهرت النتائج تفوق معاملة الفحم الحيوي مع منقوع الباميا في خفض الاستهلاك المائي الفعلي، إذ سجلت أقل قيمة بلغت 353.6 مم مقارنةً بمعاملة المقارنة التي سجلت 712.6 مم، مترافقة مع انخفاض واضح في عدد الريات وكمية ماء الري بجميع مراحل النمو. كما أدى ذلك إلى انخفاض ملحوظ في قيم معامل المحصول (KC)، مما يعكس تحسناً في كفاءة استعمال المياه وتقليل الفاقد دون التأثير سلبيًا في النمو. وتشير النتائج مجتمعةً إلى أن محسنات التربة، وبالأخص الفحم الحيوي، أسهمت بفاعلية في تقليل الاحتياجات المائية، فيما تفوق منقوع الباميا على سليكات البوتاسيوم في الحد من فقد الماء عبر النتج. كما أثبت التداخل بين المحسنات والمثبطات فاعليته الأكبر مقارنةً باستخدام كل منهما منفردًا، إذ حقق توفيرًا مائيًا قد يصل إلى نحو 50% دون الإضرار بنمو النبات. وتؤكد هذه المعطيات أهمية تبني تقنيات الإدارة المائية المتكاملة لتعزيز كفاءة استخدام المياه ودعم استدامة زراعة فستق الحقل في البيئات المعرضة للشح المائي.

الكلمات المفتاحية: تلوث التربة؛ المعادن الثقيلة (الرصاص، الكاديوم، الكوبالت، الكروم، النيكل)؛ معامل الطابوق؛ عامل التلوث (CF)؛ درجة التلوث (Cdeg).

1. Introduction:

Soil amendments are important for improving the physical properties of soil, leading to better soil structure and aeration and increased water-holding capacity. Consequently, they help improve water and air movement, plant growth, and productivity. This occurs due to changes in soil pore size distribution (Aslan et al., 2018). Soil amendments also act as insulating materials that protect plant roots, maintain moisture levels in the surrounding zone, and at the same time reduce high temperatures that are harmful to plants. Transpiration is one of the vital physiological processes in plants, as it contributes to regulating internal water balance and transporting nutrients from the soil to aerial parts, in addition to its role in cooling plant tissues (Baghyalakshmi et al., 2018). However, high rates of water loss through transpiration, especially in arid environments or under limited irrigation conditions, lead to disturbances in water balance and reduce growth efficiency and productivity (Lamiter, 2020). To reduce these water losses, several techniques have been developed, most notably the use of antitranspirants, which are materials applied to the leaf surface to reduce transpiration rates either by forming a protective film that reduces evaporation or by regulating stomatal opening and closing mechanisms (Wang et al., 2023). The effect of antitranspirants on economically important crops, such as peanut, is of particular importance in light of increasing water scarcity and the need for sustainable agricultural strategies that enhance resource-use efficiency without compromising productivity. The need for effective water management for crop production in water-deficient regions has become critical, requiring the development of effective strategies aimed at improving water-use efficiency. These practices include cultivating high-value, water-use-efficient crops in addition to suitable crop irrigation systems. Irrigation scheduling using modern systems depends on crop water requirements to maintain appropriate moisture levels in the root zone, contributing to sustainable growth and water savings of up to 40–80% compared with traditional irrigation systems. Insufficient irrigation at critical growth stages is considered the main factor affecting

peanut productivity (Balasubramanian et al., 2023). Peanut (*Arachis hypogaea* L.) is an industrial oilseed legume crop belonging to the family Fabaceae and has great economic importance due to its seeds containing a high oil content of up to 50%. It ranks second after sunflower in oil production and third after soybean and cottonseed in protein production. This crop is used to improve sandy soils with low fertility, as it contributes to the addition of organic matter to the soil. Despite its economic importance, peanut cultivation in Iraq is limited due to several problems, including the need for suitable irrigation systems and appropriate soil conditions (Manasa et al., 2015). In light of the above, this experiment was conducted with the following objectives: To study the effect of soil amendments and antitranspirants on the water requirements of peanut crop. To calculate actual water consumption (ETa), reference evapotranspiration (ETo), and crop coefficient (Kc) under the climatic conditions of Wasit Governorate.

2. Materials and Methods

2.1 Experimental site:

A field experiment was conducted during 2024 in the fields of the Agricultural Research Station belonging to the Directorate of Agriculture of Wasit Governorate, in Al-Karadhiya area, located at longitude 45°54'31.7" E and latitude 32°32'15.21" N, at an elevation of 25 m above sea level. Soil texture was silty clay loam for the first layer (0–10 cm) and clay loam for the layers (10–20 and 20–30 cm), respectively. A split-plot factorial experiment was arranged according to a randomized complete block design (RCBD). The number of experimental units was 36, with each unit measuring 3 × 3 m. Peanut seeds of a local cultivar from Diyala Governorate were sown on 26/4/2024, with two seeds per hill. Harvesting was carried out on 30/10/2024.

2.2 Soil amendments:

After land preparation through cross plowing and dividing the field into equal experimental units according to ridge planting method, soil amendments (biochar, peat moss, and perlite) were added at a rate of 127 g per plant (Duaa Najah, 2024), along with fertilizers at planting according to the recommended fertilization rates for peanut crop (25 kg urea applied in two splits and 50 kg superphosphate) (Al-Maliki, 2003).

2.3 Antitranspirants:

Okra extract and potassium silicate (Ursilic) were used as antitranspirants and applied in three doses: the first on 20/5/2024, the second on 1/7/2024, and the third on 1/8/2024.

2.4 Actual water consumption (ETa):

Actual water consumption (ETa) was calculated using the water balance equation reported by Allen et al. (1998):

$$I + P \dots\dots (1) = ETa$$

where:

I = depth of applied irrigation water (mm),

P = depth of rainfall (mm).

2.5 Reference evapotranspiration (ETo):

The pan evaporation method was used to estimate reference evapotranspiration according to the equation reported by Allen et al. (1998):

$$ET_o = EP \times KP \dots\dots (3)$$

where:

ET_o = reference evapotranspiration (mm day^{-1}),

EP = pan evaporation (mm day^{-1}),

KP = pan coefficient based on FAO tables (according to relative humidity and wind speed during the crop growing season).

2.6 Crop coefficient:

The crop coefficient (K_c) represents the ratio between actual water consumption and reference evapotranspiration and was calculated using the equation reported by Allen et al. (1998) as follows:

$$K_c = ET_a / ET_o \dots\dots (4)$$

where:

K_c = crop coefficient (dimensionless),

ET_a = actual water consumption (mm),

ET_o = reference evapotranspiration (mm).

3. Results and Discussion

3.1 Actual water consumption (ET_a) of peanut crop

The results presented in Table (1) show that each study factor had an individual effect (single interaction) on reducing water consumption of the peanut crop. Regarding soil amendments, biochar application showed the highest effectiveness, as its use reduced total water consumption by percentages ranging from 35–50% compared with the control treatment. The highest reduction was observed when combined with okra extract, where the water-saving percentage reached 50.4%. This result is consistent with the highly porous nature of biochar and its ability to retain moisture, in agreement with the findings of Lehmann and Joseph (2009) and Han et al. (2023).

Peat moss ranked second, achieving a clear reduction in water consumption ranging between 21–36% compared with the control treatment. This reduction is attributed to its high water-holding capacity, which agrees with the findings of Abdelrahman et al. (2020) and Pradhan et al. (2022) regarding the role of organic materials in enhancing soil moisture content. In contrast, perlite had a relatively lower effect, recording reductions of only 11–23%, reflecting its primary role in improving aeration rather than increasing soil water-holding capacity, as reported by Adams (2016) and Khaled et al. (2019).

Regarding the effect of antitranspirants as a single factor, okra extract reduced water consumption by 10–16% when used without any soil amendment, whereas Ursilic reduced consumption by 6–8%. The effect of okra extract is attributed to its content of viscous polysaccharides that form a layer reducing water loss, as explained by Sharma et al. (2020) and Pradhan et al. (2022). Ursilic, on the other hand, enhances the waxy layer and reduces transpiration, as reported by Zhang et al. (2022) and Li et al. (2023).

The dual interaction between soil amendments and antitranspirants resulted in the highest levels of water saving. The combination of biochar and okra extract achieved the highest efficiency overall, with a total reduction in water consumption of 50.4% compared with the control treatment, while the interaction between biochar and Ursilic resulted in a reduction of 44.6%. Reductions in the remaining interactions ranged between 17–36%, depending on the type of amendment and antitranspirant used. Differences among means were more pronounced during growth stages with high water demand, especially the maturity and harvest stage, which is consistent with the findings of Pradhan et al. (2022) regarding increased effectiveness of these treatments under drought conditions. These results support recent trends in irrigation water management that advocate combining soil moisture improvement with reducing plant water loss, as this integration leads to a clear reduction in water consumption while maintaining plant growth, as supported by the findings of Li et al. (2023), Liu et al. (2022), and Xie et al. (2021).

Table (1). Actual (ETa) and total water consumption of peanut crop during growth stages

T	Germination stage					Vegetative growth stage					Flowering & pod formation stage				Maturity & harvest stage				Total	
	IN	DI	TI	RF	ETa	NI	DI	TI	RF	ETa	IN	DI	TI	ET _a	NI	DI	TI	ET _a	NI	A W C
Biochar + okra extract	2	4.3	8.6	20	28.6	6	6.6	39.6	6.2	45.8	8	14.2	113.6	113.6	8	20.7	165.6	165.6	24	35.3.6
Biochar + ursolic acid	2	4.3	8.6	20	28.6	6	7.1	42.6	6.2	48.8	8	15.0	120.0	120.0	9	21.9	197.1	197.1	25	39.4.5
Biochar without inhibitor	2	4.3	8.6	20	28.6	7	7.2	50.4	6.2	56.6	9	15.6	140.4	140.4	10	23.4	234.0	234.0	28	45.9.6
Peat moss + okra extract	2	4.8	9.6	20	29.6	6	8.4	50.4	6.2	56.6	9	17.6	158.4	158.4	9	23.1	207.9	207.9	26	45.2.5
Peat moss + ursolic acid	2	4.8	9.6	20	29.6	7	8.6	60.2	6.2	66.4	9	17.8	160.2	160.2	9	27.6	248.4	248.4	27	50.4.6
Peat moss without inhibitor	2	4.8	9.6	20	29.6	7	8.9	62.3	6.2	68.5	10	18.2	182.0	182.0	10	27.9	279.0	279.0	29	55.9.1
Perlite + okra extract	2	5.1	10.2	20	30.2	7	9.3	65.1	6.2	71.3	9	19.9	179.1	179.1	9	29.7	267.3	267.3	27	54.7.9
Perlite + ursolic acid	2	5.1	10.2	20	30.2	7	9.6	67.2	6.2	73.4	9	21.0	189.0	189.0	10	29.7	297.0	297.0	28	58.9.6
Perlite without inhibitor	2	5.1	10.2	20	30.2	8	9.9	79.2	6.2	85.4	10	21.2	212.0	212.0	10	30.3	303.0	303.0	30	63.0.6
Without amendment + okra extract	2	5.4	10.8	20	30.8	7	10.1	70.7	6.2	76.9	9	20.6	185.4	185.4	9	33.9	305.1	305.1	27	59.8.2
Without amendment + ursolic acid	2	5.4	10.8	20	30.8	7	10.3	72.1	6.2	78.3	10	21.6	216.0	216.0	10	34.2	342.0	342.0	29	66.7.1

Without amendment and without inhibitor	2	5.4	10.8	20	30.8	8	10.5	84.0	6.2	90.2	11	21.6	237.6	237.6	1.0	35.4	354.0	354.0	31	712.6
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3.2 Actual water consumption (ETa), reference evapotranspiration (ETo), and crop coefficient (Kc)

Based on the results obtained from Table (2), the effect of different agricultural treatments (biochar, peat moss, perlite, and no amendment) combined with antitranspirants (okra extract, Ursilic, and no antitranspirant) on actual water consumption (ETa), reference evapotranspiration (ETo), and crop coefficient (Kc) during the four growth stages (germination, vegetative growth, flowering and peg formation, and maturity and harvest) can be discussed. The data showed clear variation in water performance among the studied treatments, reflecting the importance of organic amendments and biostimulants in improving water-use efficiency of field crops.

During the germination stage, ETa values were very similar among all treatments, ranging between 28.6–30.8 mm, while ETo remained constant at 42.9 mm. This indicates that differences in amendment or biostimulant type had little effect during this stage, which is characterized by slow physiological activity and limited leaf area. Kc values during this stage ranged from 0.25–0.50, which are reasonable and consistent with FAO-56 guidelines, indicating that crop coefficient values during early stages are generally low due to limited canopy cover and evaporation surface. These results are supported by González-Piqueras (2020), who reported that initial growth stages of vegetable crops under open-field or protected conditions do not require large amounts of water and that the effect of amendments is minimal at this stage.

During the vegetative growth stage, differences in water performance became more pronounced, as ETa values increased significantly due to enhanced leaf development. The lowest water consumption was recorded for the biochar + okra extract treatment (45.8 mm), whereas the highest was recorded for the no amendment + no antitranspirant treatment (90.2 mm). These results indicate the effective role of biochar in reducing soil water loss by improving soil physical properties and increasing water-holding capacity, in agreement with Singh (2022), who reported that biochar increases soil moisture retention and reduces surface evaporation. Okra extract, as a biological antitranspirant, also contributes to improved plant water uptake by stimulating root enzyme activity, consistent with González-Piqueras et al. (2020). Consequently, Kc values for treatments containing biochar and okra extract were the lowest (0.27–0.31), indicating higher water-use efficiency.

During the flowering and peg formation stage, which is the most critical stage from a physiological and yield perspective, water consumption increased markedly for all treatments, with ETa values ranging from 113.6–237.6 mm. The biochar + okra extract treatment showed clear superiority in reducing water consumption, whereas treatments lacking amendments and antitranspirants recorded the highest values. The highest Kc value (1.18) was observed in the no amendment + no antitranspirant treatment, indicating excessive water consumption relative to reference evapotranspiration and reflecting low water-use efficiency in the absence of amendments and antitranspirants, followed by peat moss and perlite treatments. These results are consistent with Abdelrahman et al. (2020), who reported that the use of growing media such as perlite or unamended soil increases water consumption due to low moisture retention, while

treatments containing biochar and peat moss showed better performance in reducing consumption without negatively affecting productivity.

Table (2). Actual water consumption (ETa), reference evapotranspiration (ETo), and crop coefficient (Kc).

T	Germination stage		Vegetative growth stage			Flowering & pod formation stage			Maturity & harvest stage		
Treatment	ETa (mm)	ETo (mm)	ETa mm	ETo mm	Kc	ETa (mm)	ETo (mm)	Kc	ETa (mm)	ETo (mm)	Kc
Biochar + okra extract	28.6	42.9	45.8	180	0.25	113.6	200.9	0.57	165.6	434.6	0.38
Biochar + ursolic acid	28.6	42.9	48.8	180	0.27	120.0	200.9	0.60	197.1	434.6	0.45
Biochar without inhibitor	28.6	42.9	56.6	180	0.31	140.4	200.9	0.70	234.0	434.6	0.54
Peat moss + okra extract	29.6	42.9	56.6	180	0.31	158.4	200.9	0.79	207.9	434.6	0.48
Peat moss + ursolic acid	29.6	42.9	66.4	180	0.36	160.2	200.9	0.80	248.4	434.6	0.57
Peat moss without amendment	29.6	42.9	68.5	180	0.38	182.0	200.9	0.91	279.0	434.6	0.64
Perlite + okra extract	30.2	42.9	71.3	180	0.39	179.1	200.9	0.89	267.3	434.6	0.61
Perlite + ursolic acid	30.2	42.9	73.4	180	0.40	189.0	200.9	0.94	297.0	434.6	0.68
Perlite without inhibitor	30.2	42.9	85.4	180	0.47	212.0	200.9	1.05	303.0	434.6	0.69
Without amendment + okra extract	30.8	42.9	76.9	180	0.42	185.4	200.9	0.92	305.1	434.6	0.70
Without amendment + ursolic acid	30.8	42.9	78.3	180	0.44	216.0	200.9	1.07	342.0	434.6	0.78
Without amendment and without inhibitor	30.8	42.9	90.2	180	0.50	237.6	200.9	1.18	354.0	434.6	0.81

During the maturity and harvest stage, ETa values reached their maximum for all treatments due to the long duration of this stage (83 days). The highest water consumption (354 mm) was

recorded in the no amendment + no antitranspirant treatment, while the lowest value (165.6 mm) was recorded in the biochar + okra extract treatment, reinforcing the high efficiency of this treatment in reducing water loss. Kc values ranged between 0.38–0.81, reflecting wide variation in treatment efficiency. This agrees with Singh (2022), who showed that biochar reduces total water use by up to 30% during later growth stages compared with unamended soil. These results also align with Mahesh et al. (2019), who indicated that the application of plant extracts such as okra extract improves the uptake of major nutrients, such as potassium and calcium, thereby enhancing water-use efficiency during fruit formation and maturity stages.

Overall, the biochar + okra extract treatment proved superior in reducing water consumption, achieving the highest water-use efficiency and the lowest Kc values across all growth stages, whereas the no amendment + no antitranspirant treatment showed the poorest performance, with high water consumption and low water-use efficiency. These findings are consistent with several studies confirming the effectiveness of organic amendments and biostimulants in rationalizing water use, such as those reported by Mahesh et al. (2019) and Singh (2022). Accordingly, these treatments can be recommended for agricultural environments suffering from water scarcity or aiming to achieve sustainable, water-efficient, and high-productivity agriculture.

Conclusion

This study shows that the water requirements of peanuts (*Arachis hypogaea* L.) under surface drip irrigation can be successfully decreased by combining soil amendments with transpiration inhibitors. By enhancing soil water retention, biochar had the greatest effectiveness among the studied amendments in reducing actual water consumption (ETa), whereas peat moss had a moderate effect and perlite the least. When it came to reducing water loss through transpiration, okra extract outperformed potassium silicate.

In comparison to the untreated control, the combination application of charcoal and okra extract reduced overall water consumption by almost 50%. This was accompanied by decreased crop coefficient (Kc) values across all growth stages. These findings show increased water-use efficiency without detrimental effects on plant development. All things considered, combining soil amendments with natural transpiration inhibitors is a workable and sustainable way to improve irrigation effectiveness and preserve water resources in peanut production in water-scarce circumstances.

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