Iraqi Journal of Market Research and Consumer Protection
(2025) 17(1): 97-102
DOI:
*Ali & Salah*

المجلة العراقية لبحوث السوق
وحماية المستهلك

# THE EFFECT OF ADDING ALUMINUM SULFATE (ALUM) AND COVER CROPS ON THE GROWTH AND YIELD OF SORGHUM IN DEGRADED SOIL

***Ali. A. A.[1*], Salah. M. A. [2]***

Department of Combating Desertification, College of Agricultural Engineering Sciences., University of Baghdad, Baghdad, Iraq, ali.ahmed1210a@coagri.uobaghdad.edu.iq

[2]Lecturer, Department of Combating Desertification, College of Agricultural Engineering Sciences, University of Baghdad, Baghdad, Iraq. salah.alagele@coagri.uobaghdad.edu.iq

**Received 2/ 8/ 2023, Accepted 4/ 9/ 2023, Published 31/ 3/ 2025**



## ABSTRACT

**Currently, more than 20% of the total global irrigated area is affected by salinity and high levels of sodium in soils, especially in arid and semi-arid regions, which makes them degraded soils with poor properties that may discourage or prevent plant growth in them. And through a global field experiment conducted during the fall agricultural season for the year 2022 in Anbar Governorate - Karma district according to the split-plot design, it included two factors, the first factor is three levels of cover crops (CC) planted alongside the main crop (Sorghum) and placed in the main panels and the second factor is four levels of aluminum sulfate (alum) (A) placed in the secondary panels and with three replications, the results showed a significant effect of all levels of aluminum sulfate addition in the indicators of growth and yield of white corn and reached the highest rate of increase in the treatments of the level of alum A3 In (plant height, leaf area, chlorophyll index and biological yield of sorghum crop) (21, 25, 16, 101)%, respectively, compared with the comparison treatment (A0), and in general, the significant effect occurred in an increasing manner with increasing alum levels. While the cover crops did not have a significant effect on the indicators of growth and yield of the main crop, except for leaf area.**

**Key words:** Cover crops, Salinity, Sodic soil, Sodium adsorption ratio, Drip irrigation.

# تأثير اضافة كبريتات الالمنيوم(الشب) ومحاصيل التغطية في نمو وانتاجية الذرة البيضاء في تربة متدهورة

***علي احمد علي[1] ، صلاح مهدي نجم[2]***

[1] قسم مكافحة التصحر، كلية علوم الهندسة الزراعية، جامعة بغداد، بغداد، العراق. ali.ahmed1210a@coagri.uobaghdad.edu.iq

[2] المدرس الدكتور، قسم مكافحة التصحر، كلية علوم الهندسة الزراعية، جامعة بغداد، بغداد، العراق. salah.alagele @coagri.uobaghdad.edu.iq

## الخلاصة

**تتأثر حاليًا أكثر من 20٪ من إجمالي المساحة المروية العالمية بالملوحة وارتفاع مستويات الصوديوم في التربة خاصة في المناطق الجافة وشبه الجافة ما يجعلها ترب متدهورة ذات خصائص رديئة قد تثبط او تمنع نمو النبات فيها. ومن خلال تجربة حقلية عامليه أجريت اثناء الموسم الزراعي الخريفي لسنة 2022 في محافظة الانبار- قضاء الكرمة وفق ترتيب القطع المنشقة (The Split-plot Design) تضمنت عاملين، العامل الأول هو ثلاث مستويات من محاصيل التغطية(CC) زرعت الى جانب المحصول الرئيسي(الذرة البيضاء) ووضعت في الالواح الرئيسة والعامل الثاني هو أربعة مستويات لكبريتات الالمنيوم (الشب) (A) وضع في الالواح الثانوية وبثلاثة مكررات، أظهرت النتائج تأثيرا معنويا لجميع مستويات إضافة كبريتات الالمنيوم في مؤشرات نمو وحاصل الذرة البيضاء وبلغت اعلى نسبة للزيادة عند معاملات مستوى الشب A3 في (ارتفاع النبات، المساحة الورقية، دليل الكلوروفيل والحاصل البيولوجي لمحصول الذرة البيضاء) (21، 25، 16، 101) % على التتابع بالقياس مع معاملة المقارنة(A0) وبشكل عام كان التأثير المعنوي يحدث بشكل**

[*] **The article is taken from the master's thesis of the first researcher .**

**تصاعدي مع زيادة مستويات الشب. في حين ان محاصيل التغطية لم تؤثر معنويا في مؤشرات نمو وحاصل المحصول** الرئيسي باستثناء صفة المساحة الورقية.

**الكلمات المفتاحية:** محاصيل التغطية، الملوحة، الترب الصودية، الري بالتنقيط.

## INTRODUCTION

The impact of climate change is in various fields and its impact is being felt all over the world. The soil is the basis of human sustenance, and one of the systems most affected by climate change, directly and indirectly, through erosion, deterioration of vegetation cover, and soil salinization, which causes a threat to food security in the future. Significantly on the cultivated land area and crop production and quality **(Al-Azawi, 2012)**. Saline soils in central and southern Iraq are characterized by high clay content and low rates of water infiltration through the soil section, which makes their reclamation more difficult compared to sandy soils **(Qureshi & Al-Falahi, 2015)**. The problem of salinity becomes more complicated when reclamation of soils that contain a high percentage of sodium (**Mohammed *et al.*, 2015)**, and for the reclamation of this type of soil, chemical improvers are needed for reclamation, such as the use of alum (aluminum sulfate) that has the ability to displace sodium Na+ from the exchange complex and replace it with aluminum ions Al+3, and thus improve soil structure and increase its porosity and permeability, and the addition of alum (aluminum sulfate) to sodium-saline soil with mineral and organic fertilizers leads to a decrease in the pH value, EC and ESP, total alkalinity, SAR, Na+, CO3-2, and HCO3-, and increased CEC, SOC, AN, AP, AK, K+, and SO4-2, these results are related to leaching of sodium from the root growth layer to the lower soil layers, and increased soil SOC content leading to improved colloidal properties and increased soil fertilizer retention (**Farag *et al.*, 2013)**. In addition to the use of chemical amendments, cover crop systems can be used as soil conditioners to reduce soil compaction and crusting, increase total soil porosity, increase water retention, facilitate soil aeration, increase soil fertility and enhance biological activity. In addition to the abundant biomass added by cover crops **(Çerçioğlu *et al.*, 2019)**. Cover crop cultivation stabilizes soil aggregates and wind speeds impede easy carrying of soil particles between growing seasons when the soil is usually bare. Cover crops may be planted between rows of crops perpendicular to the prevailing wind direction to provide a windbreak. This results in a slight decrease in wind speed and its effect is reduced by up to 50% on soils devoid of cover crops **(Rankoth *et al.*, 2021)**. One of the most important advantages of cover crop cultivation is that it increases the enzymatic and microbial activity of the soil and is an essential source of organic matter. It has a major role in the diversity of soil microbiota and the associated increase in nitrogen fixation, all of which is important for soil and environmental sustainability **(Rankoth *et al.*, 2019)**.

## MATERIALS AND METHODS

The field experiment was conducted during the fall agricultural season of 2022 in one of the private fields within - Karma District - Anbar Governorate, 5 km northwest of Baghdad, at the coordinates "54.369 33°29' N and 884 44°06'52.E. in degraded land as a result of high concentrations of salts as well as high sodium levels, according to the split-plot design (The Split-plot Design)) and with an RCBD design that included two factors, the first factor being a neutralizer. Covering seedlings with three levels (the first without cover crops, the second with Sesban crop and the third with the millet crop) were placed in the main panels, and the second factor is alum (A) with four levels (A0, A1, A2, A3) placed in the secondary panels, with an addition rate of (0, 1.8, 3.6, and 7.2 megagrams-1) in succession and with three replications, as the number of experimental units reached (36) units, the area of each unit is 4 * 4 m. Alum was added to each experimental unit according to the level assigned to it according to the design of the experiment and mixed with the soil surface to a depth of 10 cm. In order for the alum to work on improving the soil characteristics and to wash the salts, the soil was irrigated two times. A line containing 15 sockets and the distance between one socket to another is 0.2 m. 3-4 seeds were placed in each socket, then they were reduced to one plant 25 days after emergence. As for cover crops, they were planted in the form of lines between the lines of the main crop and at a distance of 0.3 m from it by 4 lines. Phosphorus was added at a level of 200 kg P2O5 hectare-1 at once when planting with the form of Dab fertilizer (P2O5 46%). Nitrogen fertilizer was added at the level of 320 kg N ha-1 in three batches, the first at planting from Dab fertilizer (N 18%). Urea fertilizer (N 46%) was added in the second batch after 50 days of planting and the third at the flowering stage. Potassium was added at a level of 100 kg K2O ha-1 in the form of potassium sulfate (K2O 50%) at once when planting and according to the fertilizer recommendation for white corn cultivation (10). The experiment was irrigated by a drip irrigation system using river water, and the irrigation time is after 50% of the moisture content of the soil has been depleted. The experiment continued until reaching final maturity and harvesting on 11/20/2022. Field and laboratory measurements were made for the white corn crop, as the height of the plant was measured from the ground surface to the top of the head by means of a measuring ruler and at the stage of full flowering **(Al-Sahoki, 1990)**, and the leaf area by measuring the length and width of the fourth leaf from the top and applying the equation of **Al-Sahoki & Jiad (2014)**, and the index of chlorophyll in the leaves by calculating the average readings of the fourth leaf of the five plants selected from each experimental unit after the flowering stage 100% by means of a chlorophyll meter SPAD-50 (Soil Plant Analysis Development) according to the method **(Francis & Piekielek, 1999)**, and the biological yield was calculated by calculating the average weight of the dry shoot (leaves and stems) added to the weight of the head after drying in an electric oven at 65 °C until the weight stabilized and multiplying the average by the plant density (Mg ha-1).

## RESULTSAND DISCUSSION

- **Plant height**

The results of the statistical analysis (Table, 1) showed a significant effect on plant height when adding alum. The addition of alum led to a significant increase in plant height, with average values of 197.4, 219.1, and 228.8 cm at alum levels A1, A2, and A3, with increased rates ranging between 5.0 - 21.7% compared to the comparison treatment (A0), which was 188 cm.

The plant as a result of activating the process of photosynthesis, increasing cell division, and encouraging the growth of meristematic tissues, as **Muhammad (2017)** indicated that there is a significant relationship between increasing the readiness of nitrogen and phosphorus and increasing plant height. This is consistent with what **Al-Luhaibi (2022)** concluded that the addition of alum led to an increase in the height of millet, rice and sorghum crops.

The results also showed (Table 1) that there was no significant effect on the plant height of the cover crops, as well as its interaction with the effect of alum. However, numerically, the results showed that the best treatment was CC2A3 with a length of 230.8 cm, while the lowest value for the NCCA0 treatment was 186.3 cm.

**Table (1):** Effect of alum addition and cover crops on plant height (cm).

| Cover crop (CC) | Alum Levels (A) | | | | Mean of Cover Crop |
|---|---|---|---|---|---|
| | A0 | A1 | A2 | A3 | |
| No Cover Crop (NCC) | 186.3 | 194.7 | 217.4 | 226.2 | 206.2a |
| Cover crop 1 (CC1) | 189.6 | 198.3 | 219.4 | 229.3 | 209.2a |
| Cover crop 2 (CC2) | 188.0 | 199.3 | 220.6 | 230.8 | 209.7a |
| LSD 0.05 | N.S | | | | N.S |
| Mean of Levels of alum | 188.0d | 197.4c | 219.1b | 228.8a | |
| LSD 0.05 | 6.6 | | | | |

- **Leave Area**

The results of the statistical analysis (Table 2) showed a significant effect on leaf area when adding alum and cover crops. The addition of alum led to a significant increase in the leaf area, as it averaged 3541cm $^2$ plant$^{-1}$ in the treatment of alum A3, with an increase of 25.2% over the comparison treatment (A0), which amounted to 2828 cm $^2$ plant$^{-1}$.

The reason may be attributed to the role of alum in reducing soil salinity and increasing the readiness of nutrients, which led to a decrease in salt stress that prevents the absorption of water and nutrients, and thus increased the ability of the plant to carry out the photosynthesis process **(Al- Luhaibi, 2022)**. The results (Table 2) showed a significant increase in the leaf area of the cover crops, as it amounted to 3239 cm $^2$ plant$^{-1}$ in the treatment of the first cover crop (CC1) and 3281cm $^2$ plant$^{-1}$ in the treatment of the second cover crop (CC2), with an increase of 1.7 and 3% compared to the comparison treatment (NCC) of 3186 cm $^2$ plant$^{-1}$. As for the interaction between alum and cover crops, it did not significantly affect the leaf area, but numerically, the results showed that the best treatment was CC2A3, which amounted to 3583 cm$^2$ plant$^{-1}$, while the lowest value was for the NCCA0 treatment, which amounted to 2793 cm$^2$ plant$^{-1}$.

**Table (2):** Effect of alum addition and cover crops on leaf area (cm$^2$ plant$^{-1}$).

| Cover crop (CC) | Alum Levels (A) | | | | Mean of Cover Crop |
|---|---|---|---|---|---|
| | A0 | A1 | A2 | A3 | |
| No Cover Crop (NCC) | 2793 | 3127 | 3325 | 3498 | 3186b |
| Cover crop 1 (CC1) | 2806 | 3156 | 3454 | 3542 | 3239a |
| Cover crop 2 (CC2) | 2884 | 3230 | 3428 | 3583 | 3281a |
| LSD 0.05 | N.S | | | | 52.3 |
| Mean of Levels of alum | 2828c | 3171b | 3402a | 3541a | |
| LSD 0.05 | 188.1 | | | | |

- **Chlorophyll index**

The results of the statistical analysis (Table 3) showed a significant effect on the chlorophyll index when adding alum and cover crops. The addition of alum led to a significant increase in the chlorophyll index, which amounted to an average value of 57.9 (Spad) at the concentration of alum A3, with an increase of 16.4% over the comparison treatment (A0), amounting to 49.7 (Spad). The increase also appeared in the levels of alum A1 and A2, where the average amounted to 55.1 and 56.6 Spad, respectively.

The reason may be attributed to the role of alum in improving the chemical and physical properties of the soil, as the chlorophyll index is used to detect the physiological state of the plant. and the extent of environmental stress to which the plant is exposed **(Ranjbar fordoei *et al.*, 2006)**.

The results (Table 3) showed that there was no significant effect on the chlorophyll index of the cover crops, as well as the interaction between them and the addition of alum.

**Table (3):** Effect of alum addition and cover crops on chlorophyll index in leaves (spad).

| **Cover crop (CC)** | **Alum Levels (A)** | | | | **Mean of Cover Crop** |
|---|---|---|---|---|---|
| | **A0** | **A1** | **A2** | **A3** | |
| No Cover Crop (NCC) | 49.1 | 54.1a | 55.7 | 57.3 | 54.1a |
| Cover crop 1 (CC1) | 49.4 | 54.7a | 56.6 | 57.7 | 54.7a |
| Cover crop 2 (CC2) | 50.6 | 55.7a | 57.4 | 58.8 | 55.7a |
| LSD 0.05 | N.S | | | | N.S |
| Mean of Levels of alum | 49.7c | 55.1b | 56.6ab | 57.9a | |
| LSD 0.05 | 2.6 | | | | |

- **Biological yield of Sorghum**

The results of the statistical analysis (Table 4) showed a significant effect on the biological yield of sorghum when adding alum. Its addition led to a significant increase in the biological yield, with an average value of 15.3 µg $H^{-1}$ at the A3 level, with an increase rate of more than double the control treatment (A0), which amounted to 7.6 µg $H^{-1}$.

The increase also appeared in the levels of alum A1 and A2, whose average values were 11.1 and 12.3 µg $H^{-1}$, with rates of increase of 46 and 62%, respectively.

The reason may be attributed to the effect of alum on improving the soil's physical and chemical properties, increasing plant height and leafy area (Tables 1 and 2), and increasing the availability of nutrients, which led to an increase in dry matter yield, grain yield, and thus biological yield **(Alagele *et al.*, 2021).**

To support this study **(Kukadia, 1983)** indicated that the yield was increased by increasing its components. The results also showed (Table 4) that there was no significant effect on the biological yield of cover crops, as well as its interaction with the addition of alum.

**Table (4):** Effect of alum addition and cover crops on biological yield (Mg $H^{-1}$).

| **Cover crop (CC)** | **Alum Levels (A)** | | | | **Mean of Cover Crop** |
|---|---|---|---|---|---|
| | **A0** | **A1** | **A2** | **A3** | |
| No Cover Crop (NCC) | 7.4 | 10.7a | 11.1 | 14.2 | 10.7a |
| Cover crop 1 (CC1) | 7.6 | 11.6a | 12.2 | 15.8 | 11.6a |
| Cover crop 2 (CC2) | 7.8 | 12.4a | 13.6 | 15.8 | 12.4a |
| LSD 0.05 | N. S | | | | N. S |
| Mean of Levels of alum | 7.6d | 11.2c | 12.3b | 15.3a | |
| LSD 0.05 | 0.9 | | | | |

## CONCLUSION

The addition of aluminum sulfate led to the displacement of sodium from the exchange surfaces and increased (plant height, leaf area, chlorophyll index, biological yield), as the application of aluminum sulfate can be used as an effective practice for the reclamation of saline and sodic lands in addition to the use of cover crop systems beside the main crop.

**REFERENCES**

1. Al- Luhaibi, T. K.. (2022). The Effect of Aluminum Sulfate Addition and Water Quality on Some Soil Characteristics and the Growth and Yield of White Sorghum (Sorghum bicolor L.). Master Thesis. faculty of Agriculture. Baghdad University.
2. Alagele, S.M., Jose S., Anderson S.H., & Udawatta R.P. (2021). Hydraulic lift: processes, methods, and practical implications for society. *Agroforestry Systems*, 95(4):641-657.
3. Al-Azawi, K. M. (2012). Effect of kind and concentration of salts and organic matter on electrical conductivity and soil reaction under leaching conditions. *The Iraqi Journal of Agricultural Sciences,* 43(3):42-51.
4. Al-Sahoki, M. a& Saddam J. (2014). Estimating the leaf area of sorghum by adopting one leaf. *Iraqi Agricultural Sciences Journal*. 45 (1): 1-5.
5. Al-Sahoki, M. M.(1990). Yellow maize production and improvement. Ministry of Higher Education and Scientific Research, University of Baghdad.
6. Çerçioğlu, M., Anderson S.H., Udawatta R.P. & Alagele S. (2019). Effect of cover crop management on soil hydraulic properties. *Geoderma*, 343:247-253.
7. Farag, F.A., El Shazely M.A., Abd Elrahman A.H., & Awaad M.S. (2013). Soil management and improvement of salt affected soils. *Iraqi Journal of Soil Science*, 4(9): 907-919.
8. Francis, D. D., & Piekielek, W. P. (1999). Assessing crop nitrogen needs with chlorophyll meters. Site-Specific Management Guidelines, Potash & Phosphate Institute. SSMG-12. Reference, 99082.
9. Kukadia, M. U., Desai, K. B., Patel, R. H., & Gupta, V. K. (1983). Line x tester analysis for combining ability in sorghum. *Gujurat Agricultural University Research Journal*, 9(1), 1-10.
10. Mohammed, L.I., El-Sahookie M.M., & Ulaiwee A.M. (2015). Performance of selected sorghum genotypes in a saline sodic soil. *Iraqi Journal of Agricultural Sciences*, 46(4).
11. Muhammad, S. H.(2017). The Effect of Potassium Spraying on Characteristics, Growth, Yield and Its Components of White Sorghum Varieties. Master Thesis. faculty of Agriculture. Muthanna University.
12. Qureshi, A. S., & Al-Falahi, A. A. (2015). Extent, characterization and causes of soil salinity in central and southern Iraq and possible reclamation strategies. *Int. Journal Eng. Res. Appl,* 5(1), 84-94.
13. Ranjbarfordoei, A., Samson, R., & Van Damme, P. (2006). Chlorophyll fluorescence performance of sweet almond [Prunus dulcis (Miller) D. Webb] in response to salinity stress induced by NaCl. *Photosynthetica*, 44, 513-522.
14. Rankoth, L. M., Udawatta, R. P., Veum, K. S., Jose, S., & Alagele, S. (2019). Cover crop influence on soil enzymes and selected chemical parameters for a claypan corn–soybean rotation. *Agriculture*, 9(6), 125.
15. Rankoth, L.M., Udawatta, R.P., Anderson, S.H., Gantzer, C.J., & Alagele, S.M. (2021). Cover crop influence on soil water dynamics for a corn–soybean rotation. Agrosystems, *Geosciences and Environment,* 4(3), e20175.