The effect of irrigation water salinity on the growth and productivity of wheat crops in the southern regions of Iraq and mitigation methods using organic soil amendments

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Abstract. *This experiment and field studies were conducted in southern Iraq in collaboration with agricultural research centers to solve the problem of salinity's impact on wheat growth and productivity in these areas, as wheat is the country's strategic food basket. Soil and water salinity is a major challenge that threatens the sustainability of the agricultural sector and food security. Therefore, addressing the problem of salinity requires concerted efforts from all parties. Needed immediate response The Ministry of Water Resources and the Ministry of Agriculture have to consider as a top priority implementing the adding value and development programs for the irrigation projects in particular, to minimize these increases of high groundwater levels. Moreover, academic research centers including universities and agriculture colleges should be encouraged to breed new wheat cultivars that are tolerant to salt stress and drought. Research findings should be incorporated into the curricula designed for agriculture as well. Regional and international cooperation with entities such as the FAO, Green Climate Fund is also imperative in preventing climate impacts, for limits water scarcity, in resource governance..*

This study examines potential scientific and practical approaches to ameliorate salinity effects with use of organic soil amendments. The findings showed that salts not only induce a decrease in yield but also cause harm to plants chemically and physiologically. Nevertheless, a field experiment carried out in southern and central Iraq has demonstrated that the use of enhancers and ameliorants like humic acid and compost, along with growing salt–tolerant cultivars can significantly enhance wheat production along with increasing crop consumptive water use efficiency.which provides a path towards more sustainable and flexible cultivation.

In sandy loam soils, wheat yield increased by 6% to 12% after adding compost, and in clay loam soils, wheat yield increased by 2% to 9%.

Keywords: *wheat, organic amendments, soil, humic acid, compost, salinity.*

1. INTRODUCTION

Wheat (Triticum aestivum) belongs to the grass family and is considered the most cultivated plant species. It is used in the production of flour. In addition to growing wheat in Iraq annually, it also grows in various regions, especially polar and tropical areas, where the crop grows in various conditions and different types of soil. The ideal climate for wheat during the growth stage is a cold, rainy winter, while the ideal climate for seed formation , the ideal climate is hot and dry (Dr. Talib et al., 2018). It blooms from the end of May to the beginning of June and is characterized by its green color. When ripe, it turns brownish-yellow and is 0.6 – 1.5 m) and produces compound grains that are the main food source for people around the world. The wheat crop goes through three stages from planting to harvest, which are called (establishment, construction, and finally production). Wheat crops grow well when rainfall increases and their productivity decreases when rainfall decreases, which leads to lower productivity in sustainable agriculture (Saadoun et al. 2023) .

One of the characteristics of wheat is that grain yield increases by 5.5 tons per hectare with full irrigation, while grain yield decreases by 20% with medium irrigation, which is 50% (Thunoon et al. 2013). The growing season also varies according to the climatic characteristics of the year, which differ from one year to another for wheat crops, and this is one of the characteristics of arid regions (Saleh, R. 2022.(

The results of the economic evaluation show that, based on experiments conducted on wheat crops, the use of improved program seeds leads to increased returns for farmers. The environmental impact assessment analysis also shows how the program has a significant positive economic impact on the national economy by increasing returns (Mohammed Khalid et al. 2022). Wheat also recorded the highest radioactive activity of potassium, specifically in the S3a wheat sample (Nada Farhan 2021).

Salinity is one of the most important factors negatively affecting agricultural production in Iraq, causing a significant decline in crop productivity. Iraq's dry climate, high temperatures, and increased evaporation rates have contributed to the deposition of salts on the soil surface. The provinces of Dhi Qar and Basra are among the areas most affected by salinity. This is because agricultural land in Dhi Qar is affected by the salinity of groundwater, where the soil in the Rifa'i district of Dhi Qar province is exposed to salinization due to high temperatures, low humidity, scarce or low rainfall, and intense solar radiation, which increases evaporation rates and thus increases salts on the surface of the land. (Badr Muhammad, 2024). In Basra, this occurs due to the high concentration of salts in the Shatt al-Arab, which reduces the area suitable for agriculture and leads to a decline in the quality and quantity of crop production.

Thus, the problem of salinity in Iraq cannot be reduced to a single factor, but is rather the result of complex interactions between natural and human factors. Furthermore, the salinity of irrigation water leads to an increase in the dry matter of crops, such as sodium, calcium, magnesium, and chloride, and a significant decrease in nitrogen, phosphorus, and potassium. (Mohammed Abdulsalam, 2012)

Salts in the soil form an impermeable layer that hinders germination and changes the mechanical properties of the soil (Zein El-Din et al. 2024). In addition, increased concentrations of magnesium, chloride, and calcium lead to higher levels of dissolved salts, which increase total hardness and conductivity. This indicates contamination of the soil near the main watercourse and mainly affects plant life (A. Khalifa Abdul Karim et al. 2021).

In another study performed on five varieties, it was found that increasing salt concentration decreased root length, wet and dry stem weight, and length of leaves (Zubai et al., 2011). The germination test also showed and reduction in the final germination and in the germination speed when increase the concentration of salts (0-200 mmol) found for all varieties used in this study (Al-Sharif et al., 2022).

For the biological, chemical, and physical properties of soil to be enhanced entirely without salt hindrance, it is worth considering the beneficial roles that organic natural amendments such as composts, humic acid, and calcium sulfate perform when addressing salinity. Biologically, they promote the microbial activity in soils which stimulates microorganisms to improve soil properties (Abdul Hamid et al., 2025). At the physical level, improvers improve the structural properties of heavy clays soil by enhancing the aeration and water penetration, decreasing surface cohesion, and reducing irrigation making salt accumulation at high κ levels due to water retention limited (Ghada Mohamed. 2024). Organic Materials Organic materials, chemically, increase the cation exchange capacity allowing soil to exchange positive ions and to mitigate those toxic elements (El-Desouki et al. 2009).

By application of soil conditioners, there is an increase in the length and number of branches, leaf area, chlorophyll content, water and nutrient retention in leaves but a decrease in proline (Al-Salhi et al. 2023). In relation to the benefi cial effects of using soil conditioners in sandy soils, there is also a certain improvement in the hydraulic properties of the soil and a facilitation of nutrient exchange as well as economic and environmental eff ects (Badr Al-Din et al. 2022). Interactions of the irrigation rates and soil amendments have pronounced impact on crops (Abdul Halim et al. 2022). Research also indicates the significance of including organic amendments as a tool for enhancing crop yield and sustaining soil fertility (Magith et al. 2024).

Application of compost in the soil is shown to be a good approach of nutrient management for plant growth on newly reclaimed calcareous soils (Mustafa Farid et al. 2025). The introduction of humic acid with wheat also provides a more efficient productivity in loading system (Salamah et al. 2023).

It is therefore imperative to explore salt tolerance genotypes due to their adaptation potential under adverse conditions for enhancing crop production here.

2. MATERIALS AND METHODS

2.1. MATERIALS

Methods This experiment was conducted using a working model farm located in the Nasiriyah district, Dhi Qar Governorate during winter growing season 2024 – 2025 / - 2025 to study some recommendations on salinity of irrigation water and its impact on wheat crop production as well as sensitivity or tolerance and adaptability of some wheat varieties to environmental conditions at the same time effect of adding organic amendments to soil. THE trial was carried out on well- plowed and -levelled clay soil, its salinity being tested. Planting of some wheat cultivars extended from mid October to mid December and included (Bahoth22 and IPA99) but also local wheat, which is grain kept by farmers since the last year production for sowing in Dhi Qar. The size of each plot was 100 m2, and the experiment were laid out in randomized complete block design (RCBD) with three replicates.

The treatments were as follows

1. Treatment 1 (T1, control): irrigation water with low salinity (no addition of fertilizer)
2. Treatment 2: high saline irrigation water (non-supplemented with fertilizer).
3. Treatment 3: high salinity irrigation water (post treated with addition of 10 tons of fertilizer).
4. Treatment 4: Irrigation with highly saline water (20 tons of fertilizer added)

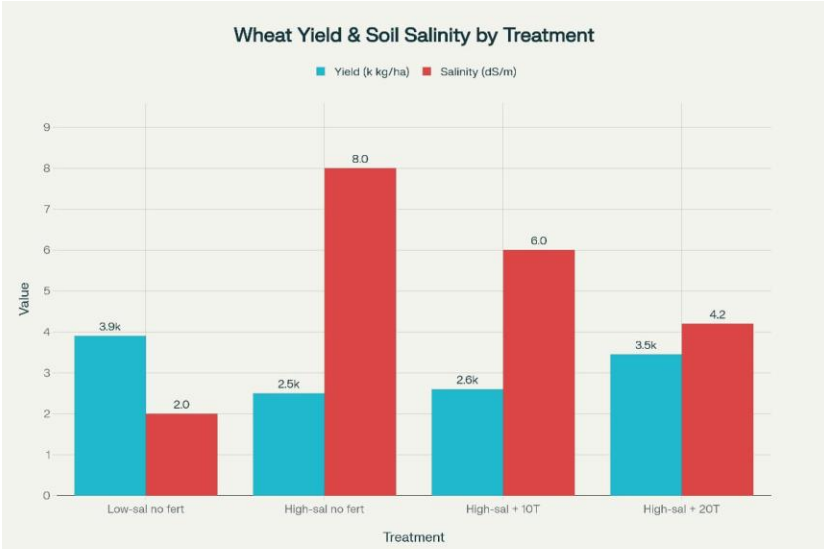
Transplanting was performed in late December 2024, and irrigation applied on the basis of a regular routine according to calculated salinity as well as actual plant requirements. Growth of plants at various intervals was recorded and an end-of-season assessment was made. The following traits were recorded for each treatment; plant height (cm), No. ears/m2, 1000-grain weight and wheat yield (kg/ha).

These data were subjected to the statistical analysis of variance (ANOVA) with SPSS (95% level, $p < 0.05$). Pairwise comparison among means was done using Tukey's test..

The ANOVA model used is a one-way analysis of variance (One-Way ANOVA) with a completely randomized experimental design (RCBD) in which four different factors for water and soil fertilizer were tested. This model examines the effect of treatment type on productivity variables to measure differences between groups. As for the statistical confidence level (p-value) , the significance level α was set at 0.05, which is the traditional level used in statistical analysis. This means that the results are considered statistically significant if the p-value is less than 0. 05, indicating that there are significant differences between treatments. The analysis also includes a test of repetitions and blocks in the design and shows the F value and degrees of freedom with a comparison of means using Tukey's HSD test to determine where there are significant differences between treatments

Table 1: Measurement of growth indicators with increased water salinity before and after adding enhancers

variable	Low-salinity water without fertilizer	high salinity water without fertilizer	High-salinity water with the addition of 10 tons of fertilizer	salinity water with the addition of 20 tons of fertilizer
Plant length (cm)	96± 2.0	75.6 ± 1.9	58.2 ± 2.3	102 ± 2.1
Crop density per square meter	340 ± 16.0	200 ± 13.0	270 ± 10.0	320± 13
Thousand Kernel Weight (grams)	43.2 ± 1.3	30± 1.2	35.7 ± 1.3	39 ± 1.2
Wheat yield (kg/ha)	3900 ± 140	2500 ± 120	2600 ± 130	3450 ± 130
Post-harvest soil salinity	2.0 ± 1.0	8.0 ± 0.26	6.0 ± 0.19	4.2 ± 0.18



3. RESULTS AND DISCUSSION

Wheat growth and productivity were monitored in all four treatments during the 2024-2025 growing season, and vital indicators were measured at the end of the season, recording plant height, number of ears per square meter, weight of 1,000 grains, total yield, and soil salinity at harvest.

We observed a marked improvement in all measured attributes between treatments group 1 (irrigation with low-salinity water without enhancers) and group 4 (high salinity with 20 tons of compost), leaving no doubt that the latter was the second best treatment, better than groups' 2 and 3.

Results in Table 1 indicated that the four treatments were significantly different with respect to all the studied variables. Best wheat growth and crop productivity were obtained from the low salinity water treatment, while decreasing trends with increasing salinity were recorded for all indicators. Significant differences were found for all indicators in each pair of treatments according to Tukey test, which proved the negative effect of irrigation water salinity on wheat.

These findings support the theory that high salt concentration in irrigation water leads to a decreased wheat growth and yield. This is attributed to an osmotic stress and a toxicity effect occurring when salt accumulates in the soil, whereby its intake into plants restricts water uptake by roots driving to water stress and weak absorption of essentials elements like calcium and potassium. Moreover, the chlorophyll content of crop leaves is greatly reduced, photosynthetic efficiency reduces and photoreduction activities weaken, dry weight of lead crop reduces So that most economies are lost..

This poses a threat to the continuation of agriculture in these areas affected by irrigation water salinity. It is not only a loss of production but also an indicator of the deterioration of environmental and administrative efficiencies in the field. There may be a direct relationship between increased irrigation water salinity and decreased crop productivity, i.e. (the higher the salinity of the water, the greater the problems and challenges faced by farmers). According to data from agricultural research centers, this decline is significant and dangerous and has direct economic implications for farmers.

According to experiments, the variety (Research 22) can withstand both salt and water stress. Wheat production data shows that Nineveh had the highest wheat production in 2024 due to favorable environmental conditions affecting production. Farmers were less environmentally efficient in fields with high salinity, and addressing salinity requires not only the application of agricultural solutions but also building farmers' capacities and providing them with expertise and information to manage their fields well (Fathy, S. H. et al., 2023).

Table 2: Comparison of the effect of compost on wheat production in different soil types

Soil type	Increase in wheat yield after compost application
sandy clay	6-21
Alluvial clay	2-9

According to the data shown in Table 2 (2), compost has proven to be highly effective in improving crop production in the various soils used in Table (2), as well as improving their physical and chemical properties, reducing the accumulation of harmful salts, and improving the soil's water retention capacity. This makes it an ideal choice for farmers in the southern and central regions of Iraq.

The amendments also contributed to reducing irrigation water leakage outside the root zone, which enhances water use efficiency and improves soil structure, promoting aeration and water retention, as well as increasing chemical reactions, which in turn reduce harmful sodium ion concentrations and promote the growth of beneficial microbes that help in the decomposition of organic matter and the release of nutrients. organic matter and release nutrients.

Also, adding organic fertilizer increases crop growth by 15% to 20% and increases crop production compared to untreated saline soil. In addition, organic fertilizer reduces salinity levels in the topsoil layers.

Commenting on the results of this study, it is clear that the research hypotheses have been largely confirmed, as high irrigation water salinity negatively affects wheat crop growth and productivity. The results showed a clear decline in growth and yield indicators in the group that used high-salinity irrigation water without organic improvements compared to the group control group that used low-salinity irrigation water.

It was found in our study that the high-salinity water is responsible for reduction of plant height, number and weight of ears and grain yield more than low-salinity water; these results are accordant with those of omewherez University-Basra-when Smti cohesion occurs which has negative effect on growth Ibrar Nia Hameed at al Wasit governorate who added that salinity caused Amanie affair on number of ear/plant ( ); did not seed many but whereas to decrease may be coordinated by this figure from reduced two aspects.

Moreover, findings of this study support the idea that application of organic amendments can improve soil properties and reduce these bad effect as described before which Application to either group significantly ($p \leq 0.05$), improve plant growth and production indicating that it is consistent with other studies since many authors studied about role of organic additives to improve soil structure and mitigated salt stress on plants according to previous studies by themselves in south Iraq [48]. Thus, the study has succeeded in achieving integration and synchronization between hypotheses established on one hand and research results as evidenced by empirical data compatible with previous scientific studies that will reinforce the credibility of the conclusions reached during investigation process bearing helpful for providing appropriate advices related to salinity problem in Iraqi agriculture.

In addition, we will include here the required vital values such as EC (electrical conductivity), pH (acidity), CEC (cation exchange capacity), and OM % (organic matter percentage.)

1- Soil analysis before planting:

A. The EC of the soil exceeded that of irrigation water with high salinity suggesting a salt deposit in the soil.
B The pH of the soiltopleachate ratio was in a suitable range for soil_lab testing, but water salinity slightly influenced the pH.
C. C- CEC was moderate and salt accumulation decreased cation exchange capacity when compared with improved soil.
D. D- The untreated soil had low levels of OM% with negative impact on SS and exchange capacity of the medium.
Soil analysis after growing and applying treatments:
A The utilisation of organic fertilizer at a rate of 20 ton/ha increased the organic matter (OM %), and this led to an improvement in soil structure.
B. EC declined in organic amendment treatments were this negative effect of salinity decreased.
C. CEC increased markedly, in the case of organic fertilization treatments, it improved soil nutrient exchange capacity.
D The pH value was relatively stable and slightly increased by the addition of organic amendments.
E. This implied the improvement of the soil physical properties, and associated increase to productivity, being that only two (2) determinants; ECsalt and %humus were affect by salinity under conventional tillage with & without organic amendments in comparison to 40% of those same critical values for no biostimulant treatment.

TECHNICAL RECOMMENDATIONS FOR FARMERS

1- Farmers should use effective irrigation methods such as drip irrigation, which reduces salt accumulation in the soil and promotes even water distribution around plant roots, as well as periodic soil washing using fresh water.
2- Farmers should use organic soil improvers such as compost (at a rate of 15 tons/hectare) and humic acid (at a rate of 1-2 kg/hectare) to improve soil properties and combat salinity.
3- In highly saline soils, it is preferable to grow crops that tolerate salinity, such as barley and beets, or fruit trees such as palm and olive trees.
4- Follow a suitable agricultural cycle, including planting alfalfa, as it is a crop that can be easily mulched and used to mulch weeds in the orchard or reduce their numbers until they disappear.
5- Farmers should also plant varieties that are resistant to fungal diseases, especially yellow rust.
6- Farmers should harvest the crop after it ripens in the early morning or evening.
7- Strategic recommendations for government and research institutions

There are several strategic recommendations for government agencies and research centers, as addressing the problem of salinity requires concerted efforts from all parties. The Iraqi Ministry of Water Resources and Ministry of Agriculture must prioritize the rehabilitation and development of drainage projects to reduce the rise in groundwater levels. In addition, research institutions such as universities and agricultural centers must focus on developing new wheat varieties that are resistant to salinity and drought, as well as integrating research results into agricultural curricula. breeding new wheat varieties that are resistant to salinity and drought, as well as integrating research findings into agricultural curricula. Regional and international cooperation with organizations such as the FAO and the Green Climate Fund is also vital to address water scarcity and manage resources sustainably.

The Iraqi government must also increase its financial and moral support for farmers and remove the obstacles that hinder wheat production, as they are responsible for implementing all recommendations related to agriculture and crop management in order to improve production and quality.

In addition to the above, agricultural guidance should play its role in directing and educating villagers and rural dwellers, especially farmers specializing in wheat cultivation, on how to utilize the resources available to them by preparing guidance activities and programs, field demonstrations, and everything else that can be used to implement practical recommendations, in addition to urging farmers to comply with all of the above.

Government agencies should activate the land reclamation law in Dhi Qar in accordance with Law 42 of 1987, as is the case in other governorates, since our governorate lacks this successful project in the districts and subdistricts. It has only been implemented in the Dawayah project in the Shatrah district. They should also plant trees in the desert areas surrounding the province to reduce desertification, which affects the rest of the agricultural land as a result of the encroachment of sand dunes, increasing soil salinity.

Studies have shown that vegetation cover increases soil moisture, which has a positive effect on its fertility and reduces its salinity.

SOURCES AND REFERENCES

A. Khalifa Abdulkarim Musbah Abdulkarim A. Saleh Amhamed Amhani. (2021). Study of the impact of untreated wastewater on some soil properties in the Ajdabiya region, Libya. Journal of Humanities and Natural Sciences, 2(12), 515-523.

Salama, Amr, Al-Jamal, Osama, & Abdul Hamid Attia. (2023). The effect of growing wheat under olive trees on the yield and quality of olive fruits. Alexandria Journal of Scientific Exchange, 44(1), 37-48.

Al-Sharif, & Abdul Basit Al-Tayeb Al-Hashimi. (2022). The effect of stress on the germination and growth of some Libyan salt-tolerant wheat varieties (Doctoral dissertation, University of Al-Zawiya).

Al-Sharif, & Abdulbasit Al-Tayeb Al-Hashimi. (2022). The effect of stress on the germination and growth of some Libyan salt-tolerant wheat varieties (Doctoral dissertation, University of Al-Zawiya).

Saleh, R. (2022). Variation in the water area for wheat and barley crops according to climate conditions at the Al-Amara station for the period 2009-2019. Misan Research Journal, 18 (35), 1-26.

Al-Salhi, Abdel Fattah Mostafa, Abu Zeid, Iman Abdel Hakim Abdullah, Al-Balak, Tarek Khalaf Ahmed, ... & Mohamed Ali Hassan. (2023). The effect of soil improvers on the growth and fruiting of pomegranate trees growing in new reclamation areas. Assiut Journal of Agricultural Sciences, 54(3), 93-106.

Abdel Hamid, Noha, Nil, Anga, Sari, & Dalal. (2025). The integrated use of biofertilizers, organic fertilizers, and mineral fertilizers to improve wheat productivity and soil fertility in calcareous soils. Alexandria Journal of Scientific Exchange, 46(2), 285-301.

Abdelhalim Jaglan, Abdelhadi Khamis, Marghani Othman, Abdelsalam, Attia Saeed, Mahmoud Mohamed, ... & Shirin Hassan. (2022). Soil moisture, yield, and productivity relationships of two sugar beet varieties affected by irrigation rates and soil amendments under drip irrigation. Alexandria Journal of Scientific Exchange, 43(2), 353-371.

Ghada Mohamed Rashid Al-Taha. (2024). The effect of adding humic acid on germination rate, some morphological traits, and protein content of three white corn varieties under saline stress conditions. Journal of Agricultural, Environmental, and Veterinary Sciences, 8(4), 1-9.

Mujahid Ismail Hamdan, Yasser Muhammad Ahmad, & Hussein Abbas Muhammad. (2021). The effect of fertilizer combinations on bread wheat productivity in several locations in Iraq. Journal of Educational and Scientific Studies, 3(13), 1-13.

Mohammad Khalid Mohammad Far, Francis Oraha Jen, Hussein Mahdi Madhi, Wathiq Abdulqahar A, Mohammad Talib Hadi, & Mohammad Jassim Akkar. (2022). Efforts to increase beer production and its impact on the real agricultural sector (A program to increase high-yield sources of wheat in Iraq: a case study). Anbar Journal of Agricultural Sciences 20 (1).

Badr Al-Din, Rasha Muhammad, Zqzouq, & Sarah. (2022). The effect of adding soil improvers to improve the hydraulic properties and solute movement of coarse-textured soil. Alexandria Journal of Scientific Exchange, 43(3), 535-542.

Muhammad Abdulsalam Al-Mukhtar Al-Bakoush. (2012). A study of the effect of irrigation with different salinity levels and increasing rates of organic fertilizer addition on wheat growth and productivity.

Mostafa Farid, Al-Shayma, Mahmoud Muhammad, Hashim, Muhammad Mahmoud, Salah, ... & Adel. (2025). The role of compost and worm compost with biochar in nutrient absorption and the growth of tomato and molokhia plants grown in calcareous sandy soil. Assiut Journal of Agricultural Sciences, 56(1), 241-260.

Maghith, & Walid. (2024). Response of Salvia hispanica L. to organic and biofertilization under organic farming conditions. Alexandria Journal of Scientific Exchange, 45(3), 409-419.

Nada Farhan Kazem. (2021). Determination of radioactive elements in some agricultural crops. Al-Mustafasiriyah Journal of Science and Education, 22(1), 1-6.

Badr Muhammad Daoud. (2024). The role of climate and its environmental impact on soil salinization in the Rifa'i district of Dhi Qar province using geographic information systems (GIS). Iraqi University Journal, 65(2).

Dr. Talib Sabr Harija, Aqil Hassan Salman, Basil Talib Ali 2018 (Wheat cultivation in Dhi Qar Governorate) Reality-Challenges-Goals

5- Al-Desouki, Muhammad Ali, Ghalab, Faraj Allah, & Mahdi. (2009). The effect of adding some organic materials on certain chemical properties and the availability of calcium and phosphorus in calcareous soils. Assiut Journal of Agricultural Sciences, 40(2), 108-135.

Zebahi Mahmoud Abad, R., Sumarin Group, S., Khayat Najad, M., & Ghulam, R. (2011). Study of the effect of salinity stress on seedling germination and growth in five different wheat genotypes. Advances in Environmental Biology, 5(1), 177-179.

Thunoon, & Ahmad Azhar. (2013). Water requirements of the wheat crop (Sham3) in the Mosul region for the 2010/2009 season. Al-Rafadain Engineering Journal, 21(2(.

Zainuddin, Abdullah Masad, Atiya, Zain Al-Abidin, Tariq Kamal, Ahmed, ... & Abdulaziz Ibrahim. (2024). The effect of saline irrigation water on soil mechanical properties, drip efficiency, and eggplant productivity in saline soil. Egyptian Journal of Agricultural Engineering, 41(1), 39-62.

Saadoun, Emad Hamid, Hammad, Saad Khalaf, Al-Janabi, Haider Abdulali Hamza, ... & Abdul Hussein Abbas. (2023). Study of mixing proportions of yellow corn and barley with local wheat grains and their effect on the quality and characteristics of the bread produced. Journal of Plant Production, 14(2), 75-77.

Fathy, S. H., Anwer, E. M., Ramadan, A. A. E., & Bargal, M. A. E. (2023). Agricultural Knowledge Management in the Agricultural Extension Organization in El-Beheira Governorate from the Viewpoint of Extension Workers Journal of the Advances in Agricultural Researches, 28(2), 250-270

Dastar, B. and Golian, A., 2022. Total versus digestible amino acid feeding in young male broilers. 14th International Poultry Symposium PB WPSA. University of Life Sciences in Lublin, Lublin, Poland. Pages, 306-307.