




Synergistic use of saline water and poultry manure for sustainable potato (*Solanum tuberosum* L.) production under calcareous soil conditions

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Abstract

This study investigates a sustainable agricultural approach to address water scarcity and soil salinity while enhancing crop productivity. A field experiment was conducted during the 2024 fall season to evaluate the combined effects of saline irrigation water and organic fertilizers on potato (*Solanum tuberosum* L.) cultivation in calcareous soils. The experimental design employed a split-plot arrangement with three replications, comparing two water quality treatments (fresh vs saline) and multiple organic fertilizer applications (poultry and cow manure at 0%, 2%, and 4% concentrations). Results demonstrated that saline water irrigation, when combined with 4% poultry manure, significantly enhanced potato growth and yield parameters. This synergistic treatment produced the highest values in key metrics: 17.6 secondary branches per plant, 2024.3 cm² leaf area, 63.1 cm plant height, and 808.67 g yield per plant. Furthermore, tuber dry matter content increased significantly under this treatment regime. The findings suggest that strategic integration of saline water resources with appropriate organic amendments can effectively mitigate salinity stress while promoting sustainable agricultural practices. This approach offers viable solutions for regions facing water scarcity and soil degradation, contributing to sustainable food production systems.

Keywords: climate resilience, poultry manure, saline water irrigation, soil health, sustainable agriculture, waste valorization, water scarcity

Introduction

Global agricultural systems face unprecedented challenges from water scarcity and soil degradation, particularly in arid and semi-arid regions. The potato (*Solanum tuberosum* L.) represents a crucial food security crop worldwide, yet its productivity is severely constrained by salinity stress. Conventional approaches to addressing these challenges often rely on freshwater resources and chemical fertilizers, which are increasingly unsustainable. *Solanum melongena* L., commonly known as eggplant, is an important vegetable of the Solanales eggplant family. In Iraq, the area under eggplant cultivation reached about 8,660 hectares in 2021. The global production of eggplant reached 41.84 million tons, 127 of which 39.17 million tons were produced in Asia. Iraq produced 387,435 tons, with an average productivity of 22.98 tons per hectare (Mostfa et al., 2025).

Potato is an important crop but threatens by

many abiotic stresses especially soil salinity. Salinity resulted low yield and decreased potato quality. Saline water contains two fold bore well water and poultry manure apply at various rate. Poultry manure improve physicochemical properties of calcareous soil. Salinity even four-fold bore well water combined with poultry manure improve potato yield and quality. Salinity at different level of salinity combined with poultry manure enhance potato growth in calcareous soil. Poultry manure applied soil moisture increase water holding capacity (Elina et al., 2021).

This research explores an innovative paradigm that transforms agricultural constraints into opportunities through the synergistic use of marginal quality water and organic amendments. By investigating the combined application of saline irrigation water and poultry manure, this study aims to develop sustainable strategies for potato production in calcareous soils, contributing to multiple

Sustainable Development Goals (SDGs), including Zero Hunger (SDG 2), Clean Water and Sanitation (SDG 6), and Climate Action (SDG 13).

This study aimed to:

Compare the effects of fresh and saline irrigation water.

Investigate the interaction between organic manure and irrigation water salinity.

Evaluate the potential of using animal waste as a sustainable alternative.

Materials and methods

Experimental Site Characterization

The study was conducted at the Experimental Farm of the Technical Agricultural College in Mosul's Rashidiya region (36°22'N, 43°07'E) during the 2024 fall season. The region experiences a semi-arid climate with an average annual rainfall of 250-300 mm. Initial soil characterization was performed to establish baseline properties (Table 1).

Table 1 - Initial physico-chemical properties of experimental soil

Chemical Properties		
Parameter	Value	Unit
pH	7.79	
EC	3.63	dS/m
Organic Matter	1.2	%
Available Nutrients		
Nitrogen	48.5	mg/kg
Phosphorus	0.06	mg/kg
Potassium	15.0	mg/kg
Physical Properties		
Sand	362.5	g/kg
Silt	297.0	g/kg
Clay	340.5	g/kg
Texture	Clay Loam	
Bulk Density	1.43	g/cm ³

*The analysis was conducted in the laboratories of Agriculture and Forestry College, University of Mosul.

The average maximum and minimum temperatures and relative humidity were recorded during the study period from the weather station as shown in Table (2).

Irrigation Water Quality

Two water quality levels were used throughout

the experiment (Table 3). Freshwater was obtained from the municipal supply, while saline water was prepared by adding natural salts to achieve the desired electrical conductivity.

Table 3 - Chemical characteristics of irrigation water sources

Parameter	Fresh Water	Saline Water	Unit
EC	3.7	374	µS/cm
pH	8.1	6.8	-
SO ₄	29	531	mg/L
Cl	70	380	mg/L
Na	80	374	mg/L
Zn	0.2	1.3	mg/L

Experimental Design and Treatments:

The experiment employed a split-plot design with three replications. Main plots were assigned to irrigation water treatments:

Freshwater irrigation

Saline water irrigation

Sub-plots received organic fertilizer treatments:

Control: No fertilizer application

Cow manure at 2%

Cow manure at 4%

Poultry manure at 2%

Poultry manure at 4%

Combined cow and poultry manure at 2% each.

with three replicates. The transactions were

distributed randomly within each sector according to the established design. Statistical analysis was carried out using the (SAS program 2017) and Duncan's multiple range test was performed at a probability level of 0.05 (Al-Rawi and Khalaf Allah, 2000).

Agronomic Management

Dutch potato seeds (Arizona variety) were planted with standard spacing of 75 cm between rows and 25 cm between plants. All cultural practices including weeding, pest control, and irrigation scheduling were uniformly applied across all treatments. The organic fertilizers were incorporated into the soil two weeks before planting to allow for initial decomposition.

Data Collection and Analysis

Growth parameters were measured one week

Table 2 - Monthly averages of maximum and minimum temperatures and relative humidity during the study period in the field.

Average Maximum Temperature (°C)	Average Minimum Temperature (°C)	Average Rainfall	Relative Humidity (%)	Months
34.2	32.5	0	28.2	September
30.2	28.5	0	31.1	October
26.3	24.8	0	40.7	November
22.9	21.4	10.9	46.1	December

before harvest, including plant height, number of secondary branches, and leaf area. At harvest, yield components including tuber number, tuber weight, and dry matter content were determined. Leaf area was measured using the photocopy-weight method described by (Saieed., 1990). Dry matter percentage was calculated as $(\text{Dry Weight}/\text{Fresh Weight}) \times 100$.

Statistical analysis was performed using SAS software (version 2017). Data were subjected to analysis of variance (ANOVA) and treatment means were separated using Duncan's Multiple Range Test at $p \leq 0.05$.

Experimental readings and measurements

First: Vegetative growth characteristics. Vegetative growth characteristics of plants were measured one week before harvesting tubers and included:

Number of secondary aerial stems (stem.plant⁻¹):

The average number of aerial stems of the same plants that were marked was calculated and the average was extracted.

Leaf area of the plant (cm². plant⁻¹): Three leaves were taken from five plants at random from the middle of each experimental unit (the "tagged plants"). The leaf was photographed using a photocopier in its natural shape and size. The entire leaf was then weighed before cutting. After that, the leaf was cut based on the photographed and drawn shape, and the shape was weighed according to what was stated by (Saieed, 1990).

Paper Area: The leaf area was calculated by gravimetric method. In this method, in principle, leaf area is estimated by weight comparison (gravimetry). This can be conducted by drawing the leaf to be estimated on a piece of paper, which results in a replica (copy) of the leaf. Then, cut out of paper and estimated it based on the ratio of the weight of the leaf replica to the total weight of the paper. The calculation of leaf area was conducted in 5th week (Santosa., 2023).

$$\text{Paper Area} = \frac{\text{Weight of the copied (cut) paper shape} \times \text{Area of the copied paper}}{\text{Weight of the copying paper}}$$

Dry Matter of Tubers: According to the fresh weight of the vegetable mass of the experimental units, then these samples were weighed while they were soft and placed in the oven at a temperature of 65°C until the weight was stable and weighed after drying. then the percentage of dry weight of the vegetable mass was calculated as follows: (Jafaar et al., 2023) :

$$\text{percentage of dry weight \%} = \left(\frac{\text{dry weight}}{\text{fresh weight}} \right) \times 100$$

Number of Tubers(tuber. Plant⁻¹): The total number of tubers per plant was calculated as follows:

$$\text{Number of tubers (tuber per plant)} = \frac{\text{total number of tuber the mensured plants}}{\text{number of plants sampled (5 plants)}}$$

Total (Kg. Plant⁻¹): The total yield per plant was calculated using the following equation:

$$\text{Yield per plant} = \frac{\text{Total yield of the measured plants}}{\text{Number of plants from which the yield was taken (5 plants)}}$$

Results and discussion

It is noted from **Table 4** that irrigation with salt water is superior to irrigation with fresh water in the average number of secondary branches per plant, and the increase rate reached 12.2%. As for the effect of waste, the treatment with poultry waste 4% was superior in giving the largest number of secondary branches to the plant, reaching 16.6 secondary branches. The interaction treatment between the irrigation factor and the organic fertilizer factor of 4% poultry waste gave a significant superiority over the remaining treatments, amounting to 17.64 secondary branches per plant, These results are consistent with their findings(Tunc et al.2023) when they studied the effect of organic and inorganic fertilization on the growth, yield and components of the bean plant.

It is noted from **Table 5** that the salt water treatment is superior to the fresh water treatment in the leaf area of the plant (square cm), as it reached 1624.1 square cm for salt water compared to 1484.1 for fresh water. As for organic fertilizer, the treatment that was fertilized with 4% poultry waste gave the largest leaf area of the plant, reaching 1795 square centimeters. As for the interaction between water and organic fertilizer, it is noted from the same table that there are different differences between the treatments, The treatment of irrigation with saline water and fertilization with poultry manure was 4% significantly superior to the other treatments and gave the largest leaf area per plant, reaching 2024.3 cm² per plant. The reason for the increase in the characteristics of vegetative growth of the plant when irrigated with salt water may be due to the salt water containing sulphate ions and high acidity, which may cause an increase in the readiness of the elements to be absorbed by the plant, as well as its containing the element zinc, Table (3), which may have a role in This may be due to the fact that zinc is involved in many vital processes in the plant, including stimulating the oxidation processes in plant cells, and is also necessary for the formation of the amino acid tryptophan , which is what it consists of Auxin (IAA)

Table 4 - Shows the effect of fresh and salt water and organic fertilization on the number of secondary branches of the plant (stem.plant⁻¹)

Water Type	Control	Poultry 2%	Poultry 4%	Cows 2%	Cows 4%	Poultry + Cows %2+%2	Water effect
Fresh Water	8.7e	12.65bcd	15.63ab	9.21de	13.7bc	13.83bc	13.14
Salt Water	8.85e	11.81cde	17.64a	14.14bc	12.99bc	9.46de	11.63
Effect of Fertilizer	8.77	12.23	16.64	11.68	13.35	11.65	

Means with the same alphabetical letters do not differ significantly according to Duncan's multiple range test at the 5% probability level.

Table 5 - Shows the effect of fresh and salt water and organic fertilization on the leaf area of the plant (cm². plant⁻¹).

Water Type	Control	Poultry 2%	Poultry 4%	Cows 2%	Cows 4%	Poultry + Cows %2+%2	Water effect
Fresh Water	1309.7c	1573.bc	1565.7bc	761d	1615bc	1621.7bc	1484.1
Salt Water	1964.3a	1805.7ab	2024.3a	1504.3bc	1580bc	1324.3c	1624.1
Effect of Fertilizer	1636	1689.3	1795	1132.65	1597.5	1473	

Means with the same alphabetical letters do not differ significantly according to Duncan's multiple range test at the 5% probability level.

Which helps to increase plant cell division and increase plant height Leaf area of the plant (Martin,2002), Zinc has other physiological roles for plants, including increasing the efficiency of protein metabolism, as it increases the accumulation of amino acids and amides and activates many enzymes involved in the formation of carbohydrates, It is essential for the functions of more than 300 types of enzymes and also enters into the composition of many enzymes such as: Carbonic anhydrase involved in CO₂ metabolism, This is because the salt water has a high content of zinc and sulfur compared to fresh water Table (3) These results are consistent with what was mentioned. Spraying zinc sulfate on potato plants caused a significant increase in vegetative growth characteristics. (Manea et al., 2019) ,As for the effect of organic fertilizer, it is noted from the same table that the treatment of fertilization with 4% poultry manure was significantly superior to the other treatments, as it recorded the highest length of 61.5 cm compared to the lowest plant length recorded at 45.3 cm in the treatment of 4% cow manure .As for the interaction treatments between irrigation and organic fertilizer, the treatment of irrigation with salt water and fertilization with 4% kg poultry manure recorded the highest significant length, reaching 63.1 cm of plant length. This may be due to the role of poultry waste in containing plant nutrients, especially nitrogen, as well as trace elements. Organic matter plays a role in holding water and maintaining the moisture of the soil surrounding the roots, increasing root growth and spread, and increasing the readiness of elements for absorption by the plant, which facilitates the absorption of mineral nutrients from the soil and helps the plant to grow Due to the increased efficiency of the photosynthesis process and thus the increased accumulation of carbohydrates produced by this process , It leads to an increase in the plant height and the number of secondary aerial stems. Table (4, 5) leads to an increase in the leaf area of the plant (Table 6). These results are consistent with what was mentioned. (Adera., 2016) The decrease in the number

of secondary branches, leaf area and plant length in cow manure treatments may be due to a decrease in the amount of elements present in cow manure (Table (3)) and a high ratio of carbon to nitrogen, which leads to a decrease in the availability of nitrogen that can be absorbed by the plant.

It is noted from Table (6) that the percentage of dry matter in salt water increased compared to fresh water, and the percentage of increase reached 1.09%. Regarding the effect of organic fertilizer, we note the presence of differences between the fertilization treatments, and the highest value was recorded in the fertilization treatment with 4% poultry waste, which reached 13.58% dry matter, compared to the lowest value recorded in the comparison treatment, which reached 11.03, with an increase rate of 18.8%. It is also noted from the same table that the best interaction was in the treatment of irrigation with saline water and fertilization with 4% poultry waste, and it did not differ significantly except with the comparison treatment. The reason for the superiority of this treatment in the percentage of dry matter may be due to the increase in the leaf area and secondary branches of the plant (Tables (4, 5, 6)), which led to an increase in the products of the photosynthesis process, which in turn caused an increase in the dry weight of the tubers (Taha, 2007). The reason for the superiority of the poultry manure fertilizer treatment in providing the highest percentage of dry matter may be due to its containing a higher percentage of nutritional elements, and it is also characterized by its rapid decomposition compared to cow manure, as it contains a low percentage of mineral elements. This is consistent with what (Al-Tamimi., 2018 , Hameed and salim , 2022 (found when adding 10 tons per hectare of poultry waste, giving it the highest value for the percentage of dry matter, reaching 17.53%, compared to the treatments of zero and 5 tons per hectare, which reached values of 16.47 and 15.53%, with an increase rate of % 12.

Table 6 - shows the effect of fresh and salt water and organic fertilization on the percentage of dry matter of tubers(%).

Water Type	Control	Poultry 2%	Poultry 4%	Cows 2%	Cows %4	Poultry + Cows 2%+2%	Water effect
Fresh Water	10.92c	12.29abc	13.34ab	13.27abc	13.13abc	13.04abc	12.67
Salt Water	11.13bc	13.06abc	13.83a	12.98abc	12.46abc	13.37ab	12.81
Effect of Fertilizer	11.03	12.68	13.59	13.13	12.80	13.21	

Means with the same alphabetical letters do not differ significantly according to Duncan's multiple range test at the 5% probability level.

Table (7) shows the effect of fresh and salt water and organic fertilization on the number of tubers per plant(Kg. Plant⁻¹).

Water Type	Control	Poultry 2%	Poultry 4%	Cows 2%	Cows 4%	Poultry + Cows 2%+2%	Water effect
Fresh Water	3.97abc	2.87cd	3.77bcd	1.63d	3.27bcd	3.63bcd	3.19
Salt Water	4.10abc	4.37abc	6.1a	3.90abc	5.23ab	5.03abc	4.79
Effect of Fertilizer	4.03	3.62	4.94	2.77	4.25	4.33	

Means with the same alphabetical letters do not differ significantly according to Duncan's multiple range test at the 5% probability level.

Table (8) shows the effect of fresh and salt water and organic fertilization on the yield of one plant (Kg.plant⁻¹)

Water Type	Control	Poultry 2%	Poultry 4%	Cows 2%	Cows 4%	Poultry + Cows 2%+2%	Water effect
Fresh Water	262e	374.67de	513.67bcd	275.33e	258.67e	474.33cde	359.77
Salt Water	514.33bce	729.67ab	808.67a	631abc	438cde	636abc	626.27
Effect of Fertilizer	388.17	552.17	661.17	453.17	348.34	555.17	

Means with the same alphabetical letters do not differ significantly according to Duncan's multiple range test at the 5% probability level.

Table (7) indicates the superiority of the salt water irrigation treatment in giving the largest number of tubers per plant, which reached (4.79 tubers per plant). We also note from the same table that the fertilization treatment with 4% poultry manure produced the highest number of tubers, amounting to 4.94 tubers per plant, and the lowest number appeared in the fertilization treatment with 2% cow manure, which amounted to 2.77 tubers per plant. As for the interaction between irrigation water and organic fertilization, the interaction treatment with saline irrigation water and fertilization with poultry manure (4%) gave the highest number of tubers, reaching 6.1 tubers per plant.

Table (8) shows the presence of a significant difference between fresh water and salt water in the yield of one plant, as irrigation with salt water was superior to irrigation with fresh water, reaching 626.27 grams for salt water compared to 359.27 grams for fresh water. It is noted from the same table that the 4% poultry fertilization treatment significantly outperformed the other treatments. Giving the highest yield to the plant, which reached (661.17) grams. As for the interaction coefficients between irrigation water and animal manure, it is noted from Table (8) that the highest yield per plant was in the treatment of irrigation with salt water and fertilization with poultry waste 4%, which amounted to (808.67) g, and the lowest yield appeared in the treatment of irrigation with fresh water and fertilization with cow manure 4%, which amounted to (258.67) g. 87, This may be due to the increase in the total number of tubers per plant (Table 7), which caused an increase in the yield per plant and an increase in the accumulation of carbohydrates produced as a result of the photosynthesis process. In

improving plant growth and increasing the total number of tubers per plant (Table 7) and the yield per plant (Table 8) These results are consistent with what was (Qiang et al., 2018 ; Ahmed et al., 2011) .

The significant improvement in yield components under saline water irrigation with organic amendments can be explained by several mechanisms. First, the organic amendments improved soil structure and water retention capacity, reducing the osmotic stress induced by saline irrigation (Bello et al., 2021). Second, the enhanced nutrient availability, particularly nitrogen and phosphorus from poultry manure, supported better plant growth and tuber development (Agbede et al.,2022). Third, the improved vegetative growth (as indicated by the parameters in Tables) resulted in greater photosynthetic capacity, supporting higher tuber yield. The increase in dry matter content under the optimal treatment combination indicates improved assimilate partitioning and storage efficiency (Jama-Rodzenska et al., 2021 , Al-Chalabi et al., 2023). This is particularly important for potato quality, as dry matter content directly influences processing quality and nutritional value. The superior performance under saline irrigation with poultry manure amendment can be attributed to several factors. Poultry manure, with its higher nutrient content and favorable C:N ratio, likely enhanced nutrient availability and improved soil physical properties, thereby mitigating salinity stress. The presence of essential micronutrients, particularly zinc, in the saline water may have contributed to improved plant growth through enhanced enzymatic activity and hormone synthesis (Bilong et al., 2022).

Conclusion

This study demonstrates that strategic management of saline water resources combined with appropriate organic amendments can significantly enhance potato productivity in calcareous soils. The synergistic effect between saline irrigation and poultry manure application offers a sustainable pathway for potato production in water-scarce regions, contributing to climate-resilient agriculture and sustainable resource utilization.

Key findings include:

Saline water irrigation combined with 4% poultry manure enhanced all growth and yield parameters

The optimal treatment increased yield by 124% compared to freshwater control

Organic amendments effectively mitigated salinity stress through improved soil conditions

This approach supports sustainable intensification of agriculture in marginal environments

The results have significant implications for agricultural sustainability in regions facing water scarcity and soil salinity challenges. Future research should focus on long-term effects of these practices on soil health and ecosystem services.

References

- Adera , K.N. 2016. Influence of Planting Depth and Entire Row Spacing on Growth , Seed Tuber Yield and Quality of Potato At Holetta Condition , Central Highlands of Ethiopia . Master thesis of Science in Horticulture , Jimma University, Ethiopia. 86f.
- Agbede, T.M., Oyewumi, A. 2022. Benefits of biochar, poultry manure and biochar–poultry manure for improvement of soil properties and sweet potato productivity in degraded tropical agricultural soils. *Resources, Environment and Sustainability* 7: 100051
- Ahmed, A.A.; Abd El-Baky, M.M.H., Zaki M.F., Abd El-Aal F.S. 2011. Effect of Foliar Application of Active Yeast Extract and Zinc on Growth, Yield and Quality of Potato Plant (*Solanum tuberosum* L.) *Journal of Applied Sciences Research* 7: 2479-2488.
- Al-Chalabi, A.T.M., Ibraheem, F.F.F., Hussein, A.M., Alsawaf, A. 2023, December). Comparison the effect of an organic nutrient (Nektafol) under production and open field condition on the growth and yield of lettuce. In *IOP Conference Series: Earth and Environmental Science* 1262: 042003.
- Al-Rawi, K.'M. Khalaf Allah, A.A.M. 2000. Design and Analysis of Agricultural Experiments.4p.
- AL-Tememe, M. S., & AL-Jadiri, D. M. (2018). Effect of adding poultry manure and spraying organic acids on yield and some components of potato (*solanum tuberosum*l.). *Journal of Kerbala for Agricultural Sciences* 5: 207–224.
- Bello, S. K., Alayafi, A. H., Al-Solaimani, S. G., & Abo-Elyousr, K. A. (2021). Mitigating soil salinity stress with gypsum and bio-organic amendments: A review. *Agronomy* 11: 1735
- Bilong, E.G., Abossolo-Angue, M., Ajebesone, F.N., Anaba, B.D., Madong, B.À., Nomo, L.B., Bilong, P. 2022. Improving soil physical properties and cassava productivity through organic manures management in the southern Cameroon. *Heliyon* 8: e09570
- Hameed, A.I., Salim, A. F. 2022. The effect of three depths of subsurface drip irrigation levels with two types of soil on the percentage of soil moisture content. *Journal Teknologi* 84: 149-157
- Jafaar, A.A., Abdulrasool, K.J. 2023. Effect Different Levels of Organic Fertilizer and Agricultural Sulfur on the Growth and Yield of Potato *Solanum tuberosum* L. In *IOP Conference Series: Earth and Environmental Science* 1158: 022037.
- Jama-Rodzenska, A., Janik, G., Walczak, A., Adamczewska-Sowinska, K., & Sowinski, J. 2021. Tuber yield and water efficiency of early potato varieties (*Solanum tuberosum* L.) cultivated under various irrigation levels. *Scientific Reports* 11: 19121
- Manea , A.I., Al-Bayati, H.J.M., Al-Taey D.K.A. 2019. Impact Of Yeast Extract , Zinc Sulphate and Organic Fertilizer Spraying on Potato Growth and Yield . *Research on Crops* 20: 95-100.
- Martin, P. 2002. Micronutrient deficiency in Asia and the Pacific. Borax Europe Limited, UK, at, 2002. IFA. Regional conference for Asia
- Mostfa, Z. A., Alsawaf, A., Al-Rubaie, O.A.F., Saadi, A.M., Al-Chalabi, A.T.M., Al-Zuhairi, F.F.A 2025. Effects of organic and amino acid fertilization on growth and yield of eggplant (*Solanum melongena* L.). *Org. Farming* 11: 127-134
- Qiang, L., Li, H., Zhang, L., Zhang, S., Chen, Y. 2018. Mulching Improves Yield and Water Use Efficiency of Potato Cropping in China; A Meta-Analysis. *Field Crops Research* 221: 50-60.
- Saieed, N.T. 1990. Studies of variation in primary productivity, growth and morphology in relation to the selective improvement of broad leaved tree species. Ph. D. Thesis National Univ. Ireland.
- Santosa, S.J. 2023 The Scientific Study of Urea Fertilizer and Cow Manure Composition on The Growth and Yield of Kailan Plants. *Acitya Wisesa: Journal of Multidisciplinary Research* 2: 20-31
- SAS (2017). Statistical Analysis System. SAS Institute. Inc. Cary Nc. 27511, USA.
- Scott, N., Chen, H. 2013. IB-IN Depth –Special Section on Nano Biotechnology Nanoscal. *Science Engineering and Agricultural Food System* 9:17-18.
- Shafeeva, E., Komissarov, A., Ishbulatov, M., Mindibayev

R., Lykasov, O. 2022. Utilization of poultry manure when cultivating potatoes in the southern steppe of the Republic of Bashkortostan. *Saudi Journal of Biological Sciences* 29:1501-1509

Taha, Farouk Abdel Aziz (2007). The effect of potassium fertilizer and soil cover on three varieties of potato (*Solanum tuberosum* L.) grown in Basra Governorate. PhD Thesis, College of Agriculture, University of Basra, Republic of Iraq.

Tunç, M., İpekeşen, S., Basdemir, F., Akinci, C., Bicer, T. 2023. Effect of organic and inorganic fertilizer doses on yield and yield components of common beans. *The Journal of Animal and Plant Sciences*. 33. 1333-1345.

Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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