Effect Irrigation Quality and Mineral Fertilization on Barley Productivity (Variety 244) and Some Nutrients Availability

Haider. A. Al-Maamori¹, Montazer. H. Al-Budeiri² and Raji A. Mousa³

¹,²,³Agriculture Research Office, Ministry of Agriculture, Iraq.

Email: haiderabb91@gmail.com

Abstract

An experiment was conducted in fields of Agricultural Research office / Al-Dibuni Research Station in Clay Loam soil, to study the coexistence with irrigation salinity using different water qualities with a recommended mineral fertilizer by the Iraqi Ministry of Agriculture, and evaluate the role of this fertilizer in maintaining the nutritional balance in soil and barley productivity. A Factorial Experiment Design was used According to RCBD design. The results showed that mineral fertilization of 100% fertilizer recommendation was significantly superior in all measured characteristics (nitrogen and phosphorus availability in soil, EC, plant height, leaf area, number of branches, 1000 grain weight, grain yield, biological yield and harvest index) which gave (46.31, 27.29 mg kg⁻¹, 5.59 dSm⁻¹, 67.44 cm, 20.41 cm²plant⁻¹, 7.66 branch plant⁻¹, 44.08g, 3.16, 11.19 Mg ha⁻¹, and 28.24%, respectively) compared with control treatment. The addition of irrigation different types affected on the measured characteristics, as the S1 treatment gave a significant values in each of (nitrogen and phosphorus availability in soil, EC, leaf area, number of branches, 1000 grain weight, grain yield, biological yield and harvest index) which gave (40.27, 23.39 mg kg⁻¹, 5.10 dSm⁻¹, 16.97 cm²plant⁻¹, 6.91 branch plant⁻¹, 40.31 g, 3.02, 10.13 Mg ha⁻¹, and 29.98%) compared with S2 treatment. The results showed the double interaction F4S3 treatment had a significant effect in all the measured characteristics (nitrogen and phosphorus availability in soil, leaf area, number of branches, 1000 grain weight, grain yield, biological yield and harvest index) which gave (48.61 and 28.97mg kg⁻¹ and 20. 92 cm²plant⁻¹, 8.06 branch plant⁻¹, 45.75g, 3.22, 11.47 Mg ha⁻¹, and 28.07%, respectively) compared with F1S2 treatment, noting F4S3 treatment did not significantly of F4S1 treatment.

Keywords: Mineral fertilizer, Irrigation salinity, Water qualities.

1.Introduction

The world faces great challenges in providing food for the peoples whose population is steadily increasing, as it is expected that the world population will reach nearly 9 billion people in 2050, which calls for increased agricultural production than it is Now [1]. The problem of water scarcity in Iraq is one of the major problems facing the agricultural sector due to the drought in recent years, as well as the continuous storage of water in neighboring countries where the sources of rivers are located, which led to thinking By using alternative sources of low quality such as drainage water and wells to compensate for this shortage of fresh water [2]. Therefore, some technics have been introduced that reduce the effect of salinity of this water, increase the penetration of roots into the soil and their absorption of nutrients and reduce the harmful effect of saline stress. To face this problem, countries of the world have relied for many years and are still using large quantities of mineral fertilizers for the purpose of increasing agricultural production in order to provide food, but these fertilizers cause a high economic cost, and some pollution in the environment, and if we add the scarcity of water resources and degradation of soils, the statistics indicate that the number of people who suffer from hunger on a daily basis reaches about 805 million people [3], and the problem of salinization of agricultural lands is one of the biggest problems facing Countries and governments, especially in arid and semi-arid areas, and the problem of soil salinity arises as a result of an increase in the concentrations of dissolved salts in the soil as a result of the accumulated additions of mineral fertilizers to the lands in an ill-considered manner, and the International Food and Agriculture Organization of the United Nations estimates that the land affected by salinity is about 800 million hectares. Area constitutes about 6% of the land area around the world [4]. To increase production, there is coexistence with the problem of salinity by adding quantities of mineral fertilizers to increase the growth and production of different crops. A study was conducted to find out the effect of levels of mineral fertilizer on the growth and yield of barley with three levels of fertilizer recommendation (0, 50 and 75%) of the fertilizer recommendation for the barley crop. The results showed superiority. Recommendation 75% in the standards of growth and readiness of elements in
the soil [5], [6]. Also showed that the presence of mineral fertilizers by 50% surpassed 25% of the fertilizer recommendation in increasing plant growth standards. The aim of the research is to study the possibility of coexistence with salinity by using different types of water with the presence of mineral fertilizer recommended by the Iraqi Ministry of Agriculture and to assess the role of this fertilizer in preservation the state of nutritional balance in the zone of root system spread.

2. Materials and Methods

The experiment was conducted at the Agricultural Research and Experiments Station of the Daboni Research Station, Agricultural Research Department/Ministry of Agriculture, on December 26, 2019. The land was plowed orthogonally and the process of leveling and smoothing was performed, after which the panels were prepared and the land was divided into experimental units. The area of each experimental unit was 9m² (3m x 3m). A sample of the field soil was taken for chemical and physical analyzes [7], as shown in Table 1, after which the treatments were distributed randomly according to the Randomized Complete Block Design (RCBD). In the form of lines between a line and another 30 cm, the plant was harvested on 5/12/2020, as samples of soil and plants were taken randomly from each experimental unit for the purpose of measuring plant growth parameters and yield and estimating the salinity in the soil as well as nitrogen and ready phosphorous in the soil of the experiment.

2.1 Factors of experience

2.1.1 First factor / irrigation water

- Irrigation water salinity of 1.2 DS M⁻¹ S1
- Irrigation water salinity of 3.5 DS M⁻¹ S2
- Irrigation water salinity of 7 DS M⁻¹ S3

2.1.2 Second factor / mineral fertilizer

- Without adding F1
- 25% of the fertilizer recommendation F2
- 50% of the fertilizer recommendation F3
- 100% of the fertilizer recommendation F4

Number of experimental units = 3 * 4 * 3 = 36

Table 1. Some chemical and physical characteristics of study soil Pre – planting.

| Property       | Value | property | value |
|----------------|-------|----------|-------|
| pH             | 7.4   | EC (1:1) | ds m⁻¹ | 5.74  |
| Ca⁺²           | 16.57 | Na⁺      | mg kg⁻¹ | 23.2  |
| Mg⁺²           | 21.75 | P        | mg kg⁻¹ | 15.3  |
| Na⁺           | 9.61  | K        | mg kg⁻¹ | 203.7 |
| K⁺            | 1     | Sand     | g Kg⁻¹ | 208   |
| Cl⁻           | 17.95 | Silt     | g Kg⁻¹ | 451   |
| SO₄²⁻         | 20.74 | Clay     | g Kg⁻¹ | 339   |
| CO₃⁻         | 1.98  | Texture  | Clay   | loam  |

3. Results

3.1 Concentrations of nitrogen and phosphorous availability in soil and electrical conductivity

3.1.1 Nitrogen concentration

The results showed Table (2) when adding the mineral fertilizer a significant superiority in nitrogen concentration of F4 treatment, with an increase 76.21% compared to F1 treatment. The table indicates that irrigation quality affected significantly on nitrogen concentration, as treatment S1 gave the best average, with an increase 31.55%, compared to treatment S2. In addition, the results showed a significant difference in double interaction, as F4S1 treatment gave the highest average 49.42
mg kg\(^{-1}\), which didn’t significantly from F4S3 treatment, which gave 48.61 mg kg\(^{-1}\) with an increase 129.32 and 125.56% respectively compared to F1S2 treatment.

**Table 2.** Effect irrigation quality and mineral fertilization on Nitrogen available (mg Kg\(^{-1}\)).

| Levels (F) | Levels (S) | Average (F) |
|-----------|------------|-------------|
|           | S1         | S2         | S3         | F1         | F2         | F3         | F4         | L.S.D (F*S) | Average (S) | L.S.D S=0.45 |
| F1        | 30.10      | 21.55      | 27.18      | 26.28      |
| F2        | 37.13      | 24.27      | 33.15      | 31.51      |
| F3        | 44.43      | 35.72      | 42.43      | 40.86      |
| F4        | 49.42      | 40.90      | 48.61      | 46.31      |

3.1.2 Phosphorus concentration

The results showed Table (3) when adding the mineral fertilizer a significant superiority in Phosphorus concentration of F4 treatment, with an increase 87.17% compared to F1 treatment. The table indicates that irrigation quality affected significantly on Phosphorus concentration, as treatment S1 gave the best average, with an increase 36.86%, compared to treatment S2. In addition, the results showed a significant difference in double interaction, as F4S1 treatment gave the highest average 29.60 mg kg\(^{-1}\), which didn’t significantly from F4S3 treatment, which gave 28.97 mg kg\(^{-1}\) with an increase 164.99 and 159.35% respectively compared to F1S2 treatment.

**Table 3.** Effect irrigation quality and mineral fertilization on Phosphorus available (mg Kg\(^{-1}\)).

| Levels (F) | Levels (S) | Average (F) |
|-----------|------------|-------------|
|           | S1         | S2         | S3         | F1         | F2         | F3         | F4         | L.S.D (F*S) | Average (S) | L.S.D S=0.38 |
| F1        | 17.27      | 11.17      | 15.30      | 14.58      |
| F2        | 21.20      | 13.50      | 19.50      | 18.07      |
| F3        | 25.50      | 20.40      | 24.57      | 23.49      |
| F4        | 29.60      | 23.30      | 28.97      | 27.29      |

The increase of irrigation salinity levels led to a decrease in nutrients availability, the standards of plant growth and plant absorption of nutrients because the effect of salt stress, the low levels of irrigation salinity wasn’t affected on plant which led to a good growth and higher content of nutrients in soil compared to the high levels of irrigation salinity, which in turn affected the nitrogen and phosphorous content in soil [8]. The increase in nitrogen concentration may be due to the availability of nitrogen for plant absorption as a result of addition urea. These results showed the positive role of mineral fertilization in increasing the nitrogen availability in soil [9]. In addition, the addition of phosphate fertilizer leads to an increase in the concentration available phosphorus in soil [10].

3.1.3 Electric Conductivity

The results showed Table (4) when adding the mineral fertilizer a significant different in EC, as F4 treatment gave the highest value, which didn’t significantly from F3 treatment with an increase 7.29 and 5.37% respectively, compared to F1 treatment. The table indicates that irrigation quality affected significantly on EC, as treatment S1 gave the best value, with a decrease 14.11%, compared to S2 treatment. In addition, the results showed there wasn’t significant difference in double interaction, as the results present F1S1 treatment gave the lowest value for EC, which indicates that fertilization contributes, a little bit, to raising the salts percentage. As well as, fresh irrigation has contributed even slightly, in reducing the salt content in soil compared to the double interaction treatments that contain an increase in the fertilizer level and a variation in the irrigation quality.
Table 4. Effect irrigation quality and mineral fertilization on Electric Conductivity (dSm\(^{-1}\)).

| Levels (F) | Levels (S) | Average (F) |
|------------|------------|-------------|
|            | S1         | S2         | S3         |
| F1         | 4.89       | 5.61       | 5.12       | 5.21       |
| F2         | 4.95       | 5.74       | 5.25       | 5.31       |
| F3         | 5.23       | 5.89       | 5.37       | 5.49       |
| F4         | 5.32       | 6.03       | 5.42       | 5.59       |
| L.S.D (F*S) | N.S       | L.S.D = 0.15 |
| Average (S)| 5.10       | 5.82       | 5.29       |

3.2 Plant growth standards

3.2.1 Plant high

The results showed Table (5) when adding the mineral fertilizer a significant superiority in nitrogen concentration of F4 treatment which didn’t significantly from F3 treatment, with an increase 11.98 and 8.48% respectively compared to F1 treatment. The table indicates there wasn’t a significantly affected of irrigation quality on plant height, as treatment S1 gave the best value. The results showed there wasn’t significant difference in double interaction, although F4S1 treatment gave the highest value of plant high.

Table 5. Effect irrigation quality and mineral fertilization on Plant High (cm).

| Levels (F) | Levels (S) | Average (F) |
|------------|------------|-------------|
|            | S1         | S2         | S3         |
| F1         | 62.33      | 58.73      | 60.06      | 60.22      |
| F2         | 63.67      | 58.33      | 63.33      | 61.78      |
| F3         | 67.33      | 63.33      | 65.33      | 65.33      |
| F4         | 70.67      | 64.00      | 67.67      | 67.44      |
| L.S.D (F*S) | N.S       | L.S.D = 3.34 |
| Average (S)| 66.00      | 61.00      | 64.08      |

3.2.2 Leaf Area

The results showed Table (6) when adding the mineral fertilizer a significant superiority in leaf area of F4 treatment, with an increase 90.39% compared to F1 treatment. The table indicates that irrigation quality affected significantly on leaf area, as treatment S1 gave the best average, with an increase 31.75%, compared to treatment S2. In addition, the results showed a significant difference in double interaction, as F4S1 treatment gave the highest value 21.50 cm\(^2\)plant\(^{-1}\), which didn’t significantly from F4S3 treatment, which gave 20.92 (cm\(^2\)plant\(^{-1}\)) with an increase 129.94 and 123.74% respectively compared to F1S2 treatment.

Table 6. Effect irrigation quality and mineral fertilization on Leaf area (cm\(^2\)plant\(^{-1}\)).

| Levels (F) | Levels (S) | Average (F) |
|------------|------------|-------------|
|            | S1         | S2         | S3         |
| F1         | 12.21      | 9.35       | 10.60      | 10.72      |
| F2         | 14.50      | 9.85       | 13.15      | 12.50      |
| F3         | 19.70      | 13.50      | 18.87      | 17.35      |
| F4         | 21.50      | 18.82      | 20.92      | 20.41      |
| L.S.D (F*S) | 0.65       | L.S.D = 0.37 |
| Average (S)| 16.97      | 12.88      | 15.88      |

3.2.3 Number of Branch

The results showed Table (7) when adding the mineral fertilizer a significant superiority in branch Number of F4 treatment, with an increase 50.19% compared to F1 treatment. The table indicates that irrigation quality affected significantly on Number of branch, as treatment S1 gave the best average, with an increase 26.32%, compared to treatment S2. In addition,
the results showed a significant difference in double interaction, as F4S1 treatment gave the highest value 8.25 branch plant$^{-1}$, which didn’t significantly from F4S3 treatment, which gave 8.06 (branch plant$^{-1}$) with an increase 82.11 and 77.92% respectively compared to F1S2 treatment.

| Levels (F) | Levels (S) | Average (F) |
|-----------|------------|-------------|
|           | $S_1$ | $S_2$ | $S_3$ |        |
| F1        | 5.49 | 4.53 | 5.30 | 5.10  |
| F2        | 6.48 | 6.75 | 5.54 | 5.59  |
| F3        | 7.43 | 5.95 | 7.05 | 6.80  |
| F4        | 8.25 | 6.67 | 8.06 | 7.66  |

Table 7. Effect irrigation quality and mineral fertilization on Number of branch (branch plant$^{-1}$).

The addition of the recommended fertilizer leads to provide the plant with the necessary nutrients, which works to improve the plant height, leaf area, dry weight, and yield, as the addition in fertilizer levels led to improvement of plant growth standards, which is reflected in the increase of photosynthesis, carbohydrates produced and Dry material accumulation of shoots. The use different types of irrigation did not significantly affect plant high, despite the superiority of fresh irrigation over saline irrigation, this may be due to the barley is a salt-tolerant crop. Saline irrigation has a negative effect on leaf area because increase salinity accumulation in the roots that leads to physiological changes in plant depending on the effect of ions presence on cell water effort in roots, biochemical functions, reducing swelling, reducing photosynthesis, and reducing the transfer of ions inside the plant. Also, the negative effect of interference in the growth standards leads to an imbalance in leaves growth and their small size, thus reducing the photosynthesis process, in addition to the inhibitory effect of salt, which works to increase the cell wall thickness as a result of plant exposure to salt stress results in reducing the cells ability of elongate and then decrease leaf area [11, 12].

3.3 Plant productivity

3.3.1 1000 grain weight

The results showed Table (8) when adding the mineral fertilizer a significant superiority in 1000 grain weight of F4 treatment, with an increase 41.28% compared to F1 treatment. The table indicates that irrigation quality affected significantly on 1000 grain weight, as treatment S1 gave the best average, with an increase 19.29%, compared to treatment S2. In addition, the results showed a significant difference in double interaction, as F4S1 treatment gave the highest value 45.95g, which didn’t significantly from F4S3 treatment, which gave 45.75g with an increase 61.96 and 61.26% respectively compared to F1S2 treatment.

| Levels (F) | Levels (S) | Average (F) |
|-----------|------------|-------------|
|           | $S_1$ | $S_2$ | $S_3$ |        |
| F1        | 34.05 | 28.37 | 31.20 | 31.20  |
| F2        | 37.85 | 29.65 | 36.15 | 34.55  |
| F3        | 43.41 | 36.60 | 42.03 | 40.68  |
| F4        | 45.95 | 40.56 | 45.75 | 44.08  |

Table 8. Effect irrigation quality and mineral fertilization on 1000 grain weight (gm).

3.3.2 Grain yield

The results showed Table (9) when adding the mineral fertilizer a significant superiority in grain yield of F4 treatment, with an increase 18.35% compared to F1 treatment. The table indicates that irrigation quality affected significantly on grain yield, as treatment S1 gave the best average, with an increase 8.63%, compared to treatment S2. In addition, the results showed a significant difference in double interaction, as F4S1 treatment gave the highest value 3.27 Mg ha$^{-1}$, which didn’t significantly from F4S3 treatment, which gave 3.22 Mg ha$^{-1}$ with an increase 24.33 and 22.43% respectively compared to F1S2 treatment.
3.3.3 Biological yield

The results showed Table (10) when adding the mineral fertilizer a significant superiority in biological yield of F4 treatment, with an increase 39.17% compared to F1 treatment. The table indicates that irrigation quality affected significantly on grain yield, as treatment S1 gave the best average, with an increase 15.37%, compared to treatment S2. In addition, the results showed a significant difference in double interaction, as F4S1 treatment gave the highest value 11.52 Mg ha\(^{-1}\), which didn’t significantly from F4S3 treatment, which gave 11.47 Mg ha\(^{-1}\) with an increase 58.24 and 57.55% respectively compared to F1S2 treatment.

Table 10. Effect irrigation quality and mineral fertilization on biological yield (Mg ha\(^{-1}\)).

| Levels (F) | Levels (S) | Average (F) |
|-----------|------------|-------------|
|           | S1         | S2          | S3          |
| F1        | 8.48       | 7.28        | 8.35        | 8.04        |
| F2        | 9.86       | 7.54        | 8.99        | 8.80        |
| F3        | 10.66      | 9.72        | 10.62       | 10.33       |
| F4        | 11.52      | 10.58       | 11.47       | 11.19       |
| L.S.D (F*S) | 0.16     |             | L.S.D(F)=0.09 |
| Average (S) | 10.13    | 8.78        | 9.86        | L.S.D(S)=0.08 |

3.3.4 Harvest Index

The results showed Table (11) when adding the mineral fertilizer a significant superiority in biological yield of F4 treatment, with a decrease 39.17% compared to F1 treatment. The table indicates that irrigation quality affected significantly on grain yield, as treatment S1 gave the best average, with an increase 15.37%, compared to treatment S2. In addition, the results showed a significant difference in double interaction, as F4S1 treatment gave the highest value 11.52 Mg ha\(^{-1}\), which didn’t significantly from F4S3 treatment, which gave 11.47 Mg ha\(^{-1}\) with an increase 58.24 and 57.55% respectively compared to F1S2 treatment.

Table 11. Effect irrigation quality and mineral fertilization on Harvest Index (%).

| Levels (F) | Levels (S) | Average (F) |
|-----------|------------|-------------|
|           | S1         | S2          | S3          |
| F1        | 32.43      | 36.13       | 31.74       | 33.43       |
| F2        | 29.92      | 34.88       | 31.48       | 32.09       |
| F3        | 29.18      | 29.63       | 28.81       | 29.21       |
| F4        | 28.39      | 28.26       | 28.07       | 28.24       |
| L.S.D (F*S) | 0.62     |             | L.S.D(F)=0.36 |
| Average (S) | 29.98    | 32.23       | 30.02       | L.S.D(S)=0.31 |

There is a role for saline irrigation in the negative impact on barley growth, and causes harmful effects, including the osmotic effect or the effect on nutritional balance, as well as the effect on the enzymatic activity that plays an important role in the plant vital activities, including the weak development of root hair growth, Or its impact on increasing water stress, which increases respiration rates and increases carbohydrate destruction rates, which negatively affected the rate of plant height, These results agree with what was obtained by [13]. Also [14] found a significant decrease in rate of height and yield of plants irrigated with saline water as a result of the increase in the salt concentration, which leads to a decrease in water absorption due to the high osmotic pressure, which affects the work of the enzymes responsible for the vital activities inside
the plant and then the lack of its growth. The results showed that the mineral fertilizer has a significant effect in increasing the yield, and the reason for this may be due to the role of mineral fertilizers in providing nutrients by increasing the availability mineral level in the soil solution, which allows the plant to absorb the appropriate amount of them that leads to an increase in vital activities that work on plant growth, obtaining the nutrients it needs and performing its biological activity, including photosynthesis [15, 16]. The increase in the amount of phosphorous absorbed by the plant as a result of the increase in the concentration soil, which reflects positively on increase in cell division and plant growth [17]. This result is consistent with what some researchers found, which improves the nutrients absorption and thus increases the production [18, 19, 20].

References

[1] Khan, M. S.; A. Zaidi and P. A. Wani. (2007). Role of phosphate solubilizing microorganisms in sustainable agriculture-A review. Agronomy for Sustainable Development, 27:29-43
[2] Al-Hamad, A. D. S. (2007). The effect of alternating the use of drip irrigation and surface irrigation on some soil properties and the efficiency of irrigation clay soils. Master’s Thesis, College of Agriculture - University of Basra. (In Arabic).
[3] The International Institute for Sustainable Development in cooperation with the Food and Agriculture Organization. December. (2014). Electronic newsletter on food security. Issue number 4.
[4] FAO. (1985). Water Quality for Agriculture Irrigation and Drainage papers.No.29.by Ayers, A-S-and D-Westcott-Rome, Italy.
[5] Faraj, H. A. (2011). The overlapping effect between local isolates of Azotobacter chroococcum and Trichoderma harzianum on nitrogen fixation and the availability of some nutrients for barley. Master thesis. College of Agriculture, University of Baghdad. (In Arabic).
[6] Al-Mamouri, H. A. F. (2020). The effect of the interaction of biological, mineral and vermicomposting fertilizers on nitrogen and phosphorous soil availability and the growth of potato (Solanum tuberosum L.) and yield. PhD thesis. College of Agricultural Engineering Sciences. University of Baghdad. (In Arabic).
[7] Salem, S. J. and N. S. Ali. (2017). Directory of Chemical Analyzes of Soil, Water, Plants and Fertilizers. Ministry of Higher Education and Scientific Research. College of Agriculture - University of Baghdad. pp: 407. (In Arabic).
[8] El-Hayani, M. K. A. (2014). The role of bio-fertilizers and ascorbic acid in maize growth under the influence of sodium chloride stress. Master Thesis, College of Agriculture, University of Baghdad. (In Arabic).
[9] Al-Juthery, H. W. & Q. M. Al-Shami. (2019). The Effect of Fertilization with Nano NPK Fertilizers on Some Parameters of Growth and yield of potato (Solanum tuberosum L.). AL-Qadisiyah Journal For Agriculture Sciences, 9(2), 225-232.
[10] Yoda, M. Q. (2018). The role of organic fertilizer’s source and the level of mineral fertilizer in some nutrients availability and growth of potato Solanum tuberosum L. and yield. Master thesis. College of Agriculture. University of Baghdad. (In Arabic).
[11] Zheng, C.; D. Jiang ; F. Liu ; T. Dai ; Q. Jing and W. Cao. (2009). Effects of salt and waterlogging stresses and their combination on leaf photosynthesis, chloroplast ATP synthesis, and antioxidant capacity in wheat. Plant Science, 176 (4): 575 – 582.
[12] Ugur BiLGiLi; Emine budakli carpici; Bulent Baris ASIK and Necmettin CELIK (2011). Root and Shoot Response of common Vetch (Vicia Sativa L.), forage pea (Pisum sativum L.) and canola (Brassica napus L.) to salt stress during early se. Turkish Journal of Field Crops, 16(1): 33-38.
[13] Al-Mamouri, A. D. S. (2004). Effect of phosphate fertilizer, soil texture and irrigation source on some soil chemical properties, fertility and wheat growth. Master Thesis, College of Agriculture, University of Baghdad. (In Arabic).
[14] Noaman, M. N. and E. S. El-Haddad.(2000). Effects of irrigation water salinity and leaching fraction on the growth of six halophyte species. The Journal of Agricultural Science, 135(3): 279-285.
[15] Cohan, J. P.; C. Hannon ; B. Houilliez, ; J. M. Gravoueille ; 2018. Effects of potato cultivar on the components of nitrogen use efficiency. Potato Research, 61: 231-246.
[16] Alsultani, M.J., Abed, H.H., Ghazi, R.A., Mohammed, M.A. , (2020), Electrical Characterization of Thin Films (TiO2: ZnO)x-y (GO)x / FTO Heterojunction Prepared by Spray Pyrolysis Technique, Journal of Physics: Conference Series, 1591(1), 012002.
[17] Abu Dahi, Y. M. and M. A. Al-Younis. 1988. Plant Nutrition Handbook. Dar Al-Kutub Establishment for Printing and Publishing - University of Mosul - Iraq. (In Arabic).
[18] Al-Juthery, H. W. & E. H. O. Al-Maamouri. (2020). Effect of Urea and Nano-Nitrogen Fertigation and Foliar Application of Nano-Boron and Molybdenum on some Growth and Yield Parameters of Potato. Al-Qadisiyah Journal for Agriculture Sciences, 10(1), 253-263.
[19] Parker, A. V. and D. J. Belbeam. (2012). A Guide to Plant Nutrition. Part I. Translatoio by Nour al-Din Shawky Ali. Ministry of Higher Education and Scientific Research - University of Baghdad. Scientific Books House Press. (In Arabic).
[20] Al-Khazali, M. M. J. (2018). Effect of different levels of irrigation salinity, vermicomposting and mycorrhiza on the growth of millet and mung and yield. Master thesis. College of Agriculture. Wasit University.