Effect of addition mineral, organic and bio-fertilizers on nitrogen, phosphorous, potassium concentration and protein of corn crop (*Zea mays* L.)

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Abstract

A field experiment was conduct in Agricultural Research Office fields / Al-Dibuni Research Station in Wasit - at spring season of 2020 in Clay Loam soil. The study aim effect of different fertilizers types in nitrogen, phosphorous, potassium concentrations and protein content in corn. A Factorial Experiment Design was used, including three levels of phosphorous fertilizer DAP (0,25,50 KgP₂O₅ ha⁻¹) representing levels P₀ P₁ P₂, two levels of organic fertilizer were 0,4 ton ha⁻¹ representing M₀,M₁ and two levels of bio fertilizer which were B₀, B₁ respectively, According to the RCBD design with three replications. Corn seeds class 106 (*Zea mays* L.) sowed in plots (2*2m²) at amount of (120 Kg seeds ha⁻¹). The Results showed that mineral, organic and bio fertilizers addition individually affected significantly of nitrogen, phosphorus and potassium concentration in dry matter, grains and protein content also, as the level P₂, M₁ and B₁ was the best concentration compared to level P₀, M₀ and B₀ respectively. Results showed the double interactions factors M₁B₁ caused a significant increasing in nitrogen, phosphorous and potassium concentration in the dry matter, with increasing percentage 111.94, 161.53 and 85.44% in sequence compared with control treatment, and the same treatment M₁B₁ significantly affected the concentration of nitrogen and phosphorus in the grains, with increasing percentage 120.91 and 86.36% respectively, Comparison with control treatment, also noticed M₁B₁ treatment had a significant effect on protein content, with an increase percentage 121.46% compared to control treatment. Results showed the triple interactions P₂M₁B₁ achieved affected significantly in nitrogen, phosphorus and potassium concentration in dry matter and grains, with increased percentage 142.86, 208.33 and 112.00%, respectively, compared with control treatment in dry matter, with increases of 145.33, 109.52 and 92.96% respectively compared with control treatment in grains. Results showed that P₂M₁B₁ treatment achieved affected significantly in protein content, with an increase percentage 144.68% compared to control treatment.

Keywords: mineral fertilizers, organic fertilizers, bio fertilizers, protein.

1. Introduction

Soil fertility and plant nutrition is an ongoing program and operations of modern management to increasing productivity or improving the quality of crops, and the addition fertilizers either to increase soil fertility or to compensate for the lack of available nutrients or maintain a good balance between nutrients, especially nitrogen, phosphorous and potassium [1]. Most of Iraqi soils, suffer from a lack of nitrogen, phosphorus and potassium, this means that fertilization increases growth and living mass, and this is the reason behind the importance of mineral fertilization in agricultural production, and although nitrogen is abundant in Earth, but mostly of it is not available for living organisms and the amount of nitrogen in Soil surface and readiness for living organisms does not exceed 0.03% [2]. In alkaline and calcareous soils there are phosphorous and potassium in compounds, as well as phosphorus associated with clay particles and organic matter, and subjected to many reactions that reduce its readiness in soils such as adsorption and sedimentation on the surface of minerals, soil particles, organic matter, carbonate minerals and the interaction of phosphorus with Calcium ions, which requires the enhancers adding, to increase their solubility in the soil and its
availability to plant [1]. The importance of potassium comes from its important role in many biological physiological processes and in stimulating many enzymatic reactions in plants, especially the transport and storage of materials represented and water relations within the plant [3, 4]. The use of organic fertilizers is important to improving soil chemical properties, fertility and contributes with mineral fertilizers to increasing the productivity of crops [5, 6]. Humus is the final and most stable product of organic matter decomposition in soil and its decomposition is very slow [7]. Biological fertilization is used instead of chemical fertilizers to provide nutrients for plant with a compensation rate of more than 25%, as well as its role in reducing environmental pollution problems and working on agriculture sustainability [8]. Integrated fertilization was used including biological fertilizers along with mineral and organic fertilizers to increase nutrients availability for plant and its impact on productivity [9]. [10] Indicated that many crops responded to biological fertilization by using PGPB (Plant Growth Promotion Bacteria) in recent years, which encouraged the manufacture of bio fertilizers. Corn is an important grain crops due to its versatility as it is used in food and in many industries such as oil and biofuels, as well as using of dry plant material for animal fodder. Therefore, the use of mineral fertilizers, including nitrogen, phosphorus and potassium, is required to increase the growth and productivity of the plant [11, 12]. The nutrient is chemically available of plant, if it is available in a form that is capable of being absorbed by the plant, and since Iraqi soils are calcareous soils, so research aims to provide available elements from various fertilizer sources and to maintain soil fertility and productivity.

2. Materials and methods

The study was carried out in field of Al-Dibuni Research Station in Wasit - Agricultural Research office at spring season of 2020 in Clay Loam soil. The land was prepared from plowing, smoothing and leveling. The land was divided into panels a distance of 2x2 m², and the irrigation process was carried out according to the plant’s total water requirement of 670 mm depending on the field capacity, by opening the main and subsidiary channels. Samples were taken from the study soil, and after drying, grinding and sieving with a 2 mm, some chemical and physical characteristics were estimated as shown in Table 1.

Table 1. Some chemical and physical characteristics of the study soil before planting.

| Properties   | value | Unit   | Properties   | value | Unit   |
|--------------|-------|--------|--------------|-------|--------|
| pH (1:1)     | 7.3   | ----   | N           | 31.21 | Mg kg⁻¹ |
| EC (1:1)     | 4.4   | dSm⁻¹ | P           | 17.34 | mg kg⁻¹ |
| CEC          | 18.7  | Cmole Kg⁻¹ | K        | 274.51 | Mg kg⁻¹ |
| O.M          | 10.3  | g kg⁻¹ | FC          | 31.57 | %      |
| Ca²⁺         | 25.34 | meq L⁻¹ | Sand       | 207   | g kg⁻¹ |
| Mg²⁺         | 20.98 | meq L⁻¹ | Silt       | 451   | g kg⁻¹ |
| K            | 0.25  | meq L⁻¹ | Clay       | 340   | g kg⁻¹ |
| Na⁺          | 21.36 | meq L⁻¹ | Texture Class | Clay Loam |
| CO₃⁻         | Nil   | meq L⁻¹ |              |       |        |
| HCO₃⁻        | 14.17 | meq L⁻¹ |              |       |        |
| SO₄²⁻        | 18.92 | meq L⁻¹ |              |       |        |
| Cl⁻          | 27.73 | meq L⁻¹ | N. of T. Bacteria | 10×3.86 | CFU g⁻¹ soil |

2.1. Experiment factors

The Factorial Experiment was carried out according to a RCBD with three replications. The study included three levels of mineral fertilizer Di Ammonium Phosphate (DAP) (50% P₂O₅) (0, 25, 50 kgP₂O₅ ha⁻¹) representing the levels P₀, P₁, and P₂ respectively. Two levels of organic fertilization (0 and 4 Mg ha⁻¹) with a symbol M₀ and M₁, the characteristics of which are shown in Table 2.
Two levels of Phosphate Solubilizing Bacteria (PSB) were used, B0 and B1. Corn seeds (Zea mays L.) class 106 was planted on lines with a plant density 120 kg ha\(^{-1}\). Nitrogen fertilizer was added at level 200 kgN ha\(^{-1}\) as urea (46%N) to complete the recommendation and potassium fertilizer at level 150 kgK ha\(^{-1}\) (50% K\(_2\)O) as potassium sulfate, for all experimental treatments in equal. The organic fertilizer mixed with the mineral fertilizers, on lines next to the planting line. The bio-fertilizer has been added with the seeds, as contaminated seed with these bacteria after preparing them and left for an hour before planting.

| properties    | value  |
|---------------|--------|
| Organic matter| 60%    |
| Nitrogen      | 4%     |
| Phosphor      | 3%     |
| Potassium     | 4%     |
| pH            | 7.2    |
| Moisture      | 10%    |
| Dry matter    | 89%    |

2.2. Soil and plant analyses

The physical characteristics such as the particles analysis, Bulk density, and field capacity were estimated by the methods shown in [13]. Cation Exchangeable Capacity, organic matter, pH, and EC as stated in [14]. The soluble of K\(^+\) and Na\(^+\) was determined by a flame photometer, and the soluble ions of carbonate, bicarbonate and chloride were determined according to [14]. The Ca\(^{++}\) and Mg\(^{++}\) soluble were determined by using (Na\(_2\)-EDTA) as reported in [15]. Soluble sulfate (SO\(_4\)\(^{-}\)) was estimated as reported [16]. The nitrogen, phosphorous and potassium availability was estimated as reported [17]. The number of total bacteria in soil was estimated before planting using Nutrient Agar medium, according to what was mentioned in [18]. Nitrogen, phosphorus and potassium concentration in dry matter and grains were estimated as stated in [19]. The nitrogen, phosphorous and potassium concentration in dry matter and grains were estimated as stated in [19]. The protein percentage was calculated according to the way that mentioned in [20]. The results were analyzed statistically using LSD 0.05 with the lowest significant difference using the Genstat program.

3. Results and discussion

3.1. Nitrogen concentration in dry matter and grains and protein content (%)

The results of tables 3, 4 and 5 showed that the levels of mineral fertilizer gave significant differences of nitrogen concentration and protein, as the level of P2 exceeded an increase 32.16, 33.83 and 33.73% compared to the level of P0 in dry matter, grains and protein, respectively. The results showed that the increase in the levels of organic fertilizer led to a significant increase of nitrogen concentration and protein, where the level M1 exceeded with an increase 55.48, 58.98 and 58.38% compared to the level M0 in dry matter, grains and protein respectively. As for the biological fertilizer levels achieved a significant differences, and the best was the level B1, which gave the highest nitrogen concentration and protein percentage, with an increase 38.55, 42.10 and 42.91% compared to the level B0 in each of dry matter, grains and protein respectively. The interference between the organic and the biological fertilizer was the only significant effect on nitrogen concentration in dry matter, grains and protein, as the best level was M1B1, which gave the highest value, with an increase 111.94, 120.91 and 121.46% compared to M0B0 in dry matter, grains and protein respectively. The results show that there are significant differences for the triple interference, as the level P2M1B1 exceeded an increase 141.86, 145.33 and 144.68% compared to the level P0M0B0, which gave the lowest value for nitrogen concentration in dry matter, grains and protein respectively.

The addition of mineral fertilization has a role in increasing the absorption of nitrogen in the plant, especially NH\(_4\), in order not to compete with the phosphate ions H\(_2\)PO\(_4\) and HPO\(_4\)\(^{-}\) for nitrogen on the sites of absorption and thus increase the concentration and absorption of nitrogen in the grains, which increased the percentage of protein in the grains, as well as its essential role in the metabolic reactions of all living organisms as all Processes in the cell use adenosine diphosphate (ADP) or triphosphate (ATP) as an energy source such as respiration and reproduction, photosynthesis, and protein biosynthesis [1]. The organic matter and its decomposition in the soil leads to an improvement in the physical and chemical properties of the soil and an increase in the elements available for absorption, especially nitrogen, as well as its nitrogen content, which leads to an increase in its availability
in the soil and thus an increase in its absorption by the plant, which is reflected positively on the concentration of nitrogen in the grains, thus increasing the percentage of protein in grains.

### Table 3. Effect of mineral, organic and bio-fertilizer on nitrogen concentration in dry matter (%).

| Levels (P) | Levels (M) | Levels (B) | P*M     |
|------------|------------|------------|---------|
| P0         | M0         | 1.29       | 1.33    | 1.31 |
|            | M1         | 1.60       | 2.60    | 2.10 |
|            | M0         | 1.30       | 1.77    | 1.54 |
|            | M1         | 2.03       | 2.80    | 2.42 |
|            | M0         | 1.44       | 2.15    | 1.80 |
|            | M1         | 2.31       | 3.12    | 2.72 |
| LSD (0.05 )| 0.187      | N.S        |         |
| P          | P0         | 1.45       | 1.97    | 1.71 |
| B*P        | P1         | 1.67       | 2.29    | 1.98 |
|            | P2         | 1.88       | 2.64    | 2.26 |
| LSD (0.05 )| N.S        | 0.093      |         |
| M          | M0         | 1.34       | 1.75    | 1.55 |
|            | M1         | 1.98       | 2.84    | 2.41 |
| LSD (0.05 )| 0.108      | 0.076      |         |
| B          |             | 1.66       | 2.30    |      |
| LSD (0.05 )| 0.076      |            |         |

### Table 4. Effect of mineral, organic and bio-fertilizer on nitrogen concentration in grains (%).

| Levels (P) | Levels (M) | Levels (B) | P*M     |
|------------|------------|------------|---------|
| P0         | M0         | 1.50       | 1.51    | 1.51 |
|            | M1         | 1.79       | 3.11    | 2.45 |
|            | M0         | 1.50       | 2.10    | 1.80 |
|            | M1         | 2.20       | 3.36    | 2.78 |
|            | M0         | 1.58       | 2.51    | 2.05 |
|            | M1         | 2.81       | 3.68    | 3.25 |
| LSD (0.05 )| 0.277      | N.S        |         |
| P          | P0         | 1.65       | 2.31    | 1.98 |
| B*P        | P1         | 1.85       | 2.73    | 2.29 |
|            | P2         | 2.20       | 3.10    | 2.65 |
| LSD (0.05 )| N.S        | 0.139      |         |
| M          | M0         | 1.53       | 2.04    | 1.78 |
|            | M1         | 2.27       | 3.38    | 2.83 |
| LSD (0.05 )| 0.160      | 0.113      |         |

| B(0.05)    | 1.9        | 2.7        |
| LSD (0.05) | 0.113      |            |
Table 5. Effect of mineral, organic and bio fertilization on protein content of grains (%).

| Levels (P) | Levels (M) | Levels (B) | P*M |
|-----------|------------|------------|-----|
|           | B0         | B1         |      |
| P0        | 9.40       | 9.44       | 9.42 |
| M0        | 11.19      | 19.44      | 15.31|
| M1        | 9.38       | 13.13      | 11.25|
| P1        | 13.75      | 21.00      | 17.38|
| M0        | 9.88       | 15.69      | 12.78|
| M1        | 17.56      | 23.00      | 20.28|
| P2        | 9.55       | 12.75      | 11.15|
| M0        | 14.17      | 21.15      | 17.66|
| M1        | 10.29      | 14.44      | 12.36|
| LSD (0.05 ) | 1.73   | N.S        |      |
| B*P       | 11.56      | 17.06      | 14.31|
| P1        | 13.72      | 19.34      | 16.53|
| LSD (0.05 ) | N.S   | 0.87       |      |
| M         | 11.86      | 16.95      |      |
| LSD (0.05 ) | 0.71   |            |      |

3.2. Phosphorus concentration in dry matter and grains (%):

Tables 6 and 7 showed that the levels of mineral fertilizer gave significant differences of phosphorus concentration, as the level P2 exceeded an increase 36.84 and 25.92% compared to the level P0 in dry matter and grains, respectively. The results showed the increasing of organic fertilizer levels led to a significant increase of phosphorus concentration, where the M1 gave the highest concentration with an increase 64.70 and 44.00% compared to M0, which gave the lowest phosphorus concentration in dry matter and grains, respectively. The addition of biological fertilizer had a significant effect, and the level B1 was superior in increasing of phosphorus concentration, with an increase 50.00 and 30.76% compared to the level B0 in both dry matter and grains, respectively. The results showed that there are not significant differences in double interference, except for interference between organic and biological fertilizers in phosphorus concentration of dry matter and grains, Significant differences were observed, and M1B1 was the best, which gave the highest value of phosphorus concentration, with an increase 161.53 and 86.36%, compared to the level M0B0 in dry matter and grains, respectively. The results showed that there are significant differences of triple interference, as P2M1B1 level gave the highest value for phosphorus concentration with an increase 208.33 and 109.52% compared to P0M0B0 in dry matter and grains respectively. The increased levels of mineral fertilizer added led to an increase in the availability of phosphorus in the soil that could be absorbed by the roots, which in turn was reflected in the concentration of phosphorus in the plant, as phosphorus strengthens and activates the root system of plants and thus increases the absorption of nutrients, including phosphorous [4]. In addition, to added organic fertilizer containing phosphorus and its role of increasing the availability of phosphorus when it is dissolved in the soil [10]. In addition to the presence of phosphate-dissolving bacteria in the root environment, it contributed to increasing the phosphorous availability in the soil from its various sources, as it contributed to dissolving various calcium phosphates such as mono, di- and triple calcium phosphate insoluble to dissolved by the effect of phosphorus-dissolving organisms and thus encouraged the absorption of phosphorus by the plant [6].
Table 6. Effect of mineral, organic and bio-fertilizer on phosphorus concentration in dry matter (%).

| Levels (P) | Levels (M) | B0   | B1   | P*M |
|------------|------------|------|------|-----|
| P0         | M0         | 0.12 | 0.14 | 0.13|
|            | M1         | 0.18 | 0.32 | 0.25|
| P1         | M0         | 0.13 | 0.21 | 0.17|
|            | M1         | 0.23 | 0.33 | 0.28|
| P2         | M0         | 0.15 | 0.26 | 0.21|
|            | M1         | 0.27 | 0.37 | 0.32|
| LSD (0.05 )|            | 0.027|      | N.S |
| B*P        | P0         | 0.15 | 0.23 | 0.19|
|            | P1         | 0.18 | 0.27 | 0.23|
|            | P2         | 0.21 | 0.32 | 0.26|
| LSD (0.05 )|            |      | 0.014| M   |
| M*B        | M0         | 0.13 | 0.20 | 0.17|
|            | M1         | 0.23 | 0.34 | 0.28|
| LSD (0.05 )|            | 0.016| 0.011|     |

3.3. Potassium concentration in dry matter and grains (%)

Tables 8 and 9 showed that the levels of mineral fertilizer gave significant differences of potassium concentration, as the level P2 exceeded an increase 26.53 and 23.32% compared to P0 level in dry matter and grains, respectively. The results showed that increasing the levels of organic fertilizer led to a significant increase of potassium concentration, as M1 level outperformed it in
giving it the highest rate with an increase 42.97 and 37.88% compared to M0 level in dry matter and grains, respectively. As for the levels of biological fertilizer achieved significant differences, and the best was B1, which gave the highest rate, with an increase 11.78 and 25.95% compared to B0, which gave the lowest rate in dry matter and grains respectively. The results showed that the interference between organic and biological fertilizers in potassium concentration in dry matter gave significant differences, and the best was M1B1, which gave the highest value, with an increase 85.44% compared to M0B0 in dry matter. The results also showed that there are significant differences for triple interference, as the level P2M1B1 exceeded of potassium concentration with an increase 112 and 92.96% compared to level P0M0B0, which gave the lowest value of potassium concentration in dry matter and grains respectively.

Mineral, organic and biological fertilization has an important role in increasing the availability of nutrients in the soil and increasing the possibility of their absorption by the roots, which led to an increase in the content of these elements, including potassium. As well as the promotional relationship between nitrogen and potassium in absorption by plants. In addition to the role of organic fertilizer in improving many physical and chemical properties and improving the availability of nutrients, as well as the potassium content of added fertilizer and its role in increasing the availability of potassium in the soil. The role of biological fertilization is also important in improving the level of potassium in the plant and improving its growth through the secretion of growth regulators, the most important of which are oxins, gibberellins, and cytokines that encourage plant absorption of nutrients [7, 8].

| Table 8. Effect of mineral, organic and bio-fertilizer on potassium concentration in dry matter (%). |
|---|---|---|---|---|
| Levels | Levels (M) | Levels (B) | P*M |
| (P) | B0 | B1 | B0 | B1 | P*M |
| P0 | M0 | 2.00 | 2.20 | 2.10 |
|   | M1 | 2.50 | 3.70 | 3.10 |
| P1 | M0 | 2.10 | 2.70 | 2.40 |
|   | M1 | 3.01 | 3.90 | 3.46 |
| P2 | M0 | 2.30 | 3.21 | 2.76 |
|   | M1 | 3.42 | 4.24 | 3.83 |
| LSD (0.05 ) | 0.26 | N.S | P |
| B*P | P0 | 2.25 | 2.95 | 2.60 |
|   | P1 | 2.55 | 3.30 | 2.93 |
|   | P2 | 2.86 | 3.73 | 3.29 |
| LSD (0.05 ) | N.S | 0.13 | M |
| M*B | M0 | 2.13 | 2.71 | 2.42 |
|   | M1 | 2.98 | 3.95 | 3.46 |
| LSD (0.05 ) | 0.15 | 0.11 | B |
| LSD (0.05 ) | 2.56 | 3.33 |

| Table 9. Effect of mineral, organic and bio-fertilizer on potassium concentration in grains (%). |
|---|---|---|---|---|
| Levels | Levels (M) | Levels (B) | P*M |
| (P) | B0 | B1 | B0 | B1 | P*M |
| P0 | M0 | 2.70 | 2.90 | 2.80 |
|   | M1 | 3.40 | 4.71 | 4.06 |
| P1 | M0 | 2.70 | 3.70 | 3.20 |
|   | M1 | 4.03 | 4.92 | 4.47 |
| P2 | M0 | 3.10 | 4.20 | 3.65 |
|   | M1 | 4.40 | 5.21 | 4.80 |
| LSD (0.05 ) | 0.24 | N.S |
## Conclusion

Notes from the results that the treatment P2M1B1 gave the highest values, indicating that this level of mineral fertilizer with biological and organic fertilization gave very good results and there is no need for fertilizing with a higher level of mineral fertilizer. In addition, organic fertilization alone or with bio fertilization gave more results than mineral fertilization. Here, it must be said that the added just a mineral fertilizer wasn’t enough because the corn requirements for the nutrients are higher than this level, so once the organic and biological fertilizers were added, the qualities improved.

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