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# Effect of Chemical NPK, Organic and Foliar (High Potash) Fertilizers on Potato Growth and Tuber Yield

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## Abstract

A field experiment was conducted in spring season 2017 in Babylon, Iraq, to study the effect of fertilization types (as individual or interaction) on growth and tuber yield of potato (Revera variety). The experiment included four levels of Nitrogen-Phosphorus-Potassium (15-15-15): (50, 100, 150 and 200 kg/ha), two levels of organic fertilizer (0 and 12 tons.ha$^{-1}$ of fermented and decomposed palm leaves, and two levels of foliar fertilizer (control and spraying of 1% high potash soluble fertilizer (36% $K_2O$, 15% N and 15% $P_2O_5$). Tuber seeds were planted on 16/01/2017. Randomized complete block design with three replications was used. The results showed that addition of high level of compound fertilizer significantly increased vegetative growth (plant height, number of leaves, leaf area and chlorophyll) and tuber yield to 32.060 t ha$^{-1}$, compared to low level (50 kg/ha) which achieved 24.770 t ha$^{-1}$. Foliar fertilizer only increased leaf area, whereas organic fertilizers caused a significant increases of plant length, leaf area and increasing tuber yield to 29.260 ha$^{-1}$.

**Keywords:** Potato; Soil fertilizer; Foliar fertilizer; Organic fertilizer

## Introduction

Potato (*Solanum tuberosum* L.) is an important source of energy and contains high amounts of carbohydrates and minerals (Muthoni and Nyamongo, 2009). Iraqi farmers added large amounts of chemical fertilizer. Chemical fertilizers constitute a high proportion of production costs, and the extravagance in adding is a great harm to the environment and human beings (Adediran et al., 2004). Plants consume less than half of the soil's fertilizer and the residual were washing , stabilization in the soil or contributing to air pollution by volatility (Taiz and Zeiger, 2010). Nitrogen and phosphorus are among the most polluting elements, especially in poor field management (Havlin et al., 2005). The trend began to reduce chemical fertilizers adding and to find alternative methods, including organic fertilizer to increase plant production and reduce environmental pollution, as well as improving soil physical, chemical and biological stats (Samra and Said, 2011). Agbede et al (2008) and Appireddy et al (2008) found that organic fertilizer is an important source for supplying important nutrients and prevent fixation, and increasing soil biota activity, which encourages biochemical and enzymatic activity that reflected positively in plant nutrition. Foliar fertilization is one of the most important methods of plant nutrition and maintaining the nutritional balance within the plant (Jasim et al., 2013), which may be disturbed for many reasons, especially during the period of composition of potato tubers. Alberto and (2000), found that potatoes need active vegetative parts that able to supply the tubers with the necessary carbohydrates, and that the chemical fertilizers share the important metabolic processes of the plant, but the increase or decrease causes physiological imbalance.

The objective of this study was to study potato crop response to fertilizer type (soil chemical fertilizer, organic fertilizer and foliar fertilization as individual or interaction) on potato crop in Babylon Governorate, Iraq.

## Materials and methods

The experiment was carried out in Babylon, Iraq, during spring of 2017 in loam sandy soil (table 1), as factorial experiment according to randomized complete block design (RCBD) with three replications to study the effect of four levels of compound fertilizer NPK (15-15-15) : 50, 100, 150 and 200 kg $ha^{-1}$, two levels (control and spraying of 1%) of foliar fertilizer (high potash), which contains ($K_2O$ 36%, 15% N and 15% $P_2O_5$) and two levels of organic fertilizer (control and 12 $t.ha^{-1}$) of palm residue fermented and decomposed (Table 2) , added under the cultivation line by 15 cm after planting tubers before irrigation. The field soil was prepared by leaving spaces of one meter between the replications and between each experimental unit and the other. Each experimental unit included 4 ridges ( 3 m length, and 1 m apart). Similar tubers of Revera cultivars were planted at a distance of 25 cm on 16/1/2017, at the top of the ridges and 15 cm deep. Foliar fertilizer was sprayed early morning until full wetness after 70 days of planting. Other plant and soil management were conducted according to recommendations. After 60 days from planting, chlorophyll content was determined and leaf area average was calculated by Scan Leaf Area Meter. At maturity after 105 days of planting, plant height, number of leaves and number of air stems were measured as average of 5 random plants per experimental unit. The data were analyzed according to the variance analysis and the means were compared according to the least significant difference ($LSD_{0.05}$).

**Table 1.** Physical and chemical characteristic of soil farm

| Adjective | Value | Adjective | Value |
|---|---|---|---|
| pH | 7.56 | O.M. | 1.7 % |
| EC | 2.3 ds/m | Sand | 37.5 % |
| Na | 237.4 ppm | Silt | 59 % |
| P | 0.25 ppm | Clay | 3.5 % |
| K | 21.7 ppm | Soil texture | Silt Loam |

**Table2.** Analysis of organic fertilizer

| Property | Value | Property | Value | Property | Value |
|---|---|---|---|---|---|
| EC ($ds.m^{-1}$) | 2.66 | Ca % | 2.93 | Fe % | 0.423 |
| pH | 7.04 | Mg % | 0.58 | Zn % | 0.055 |
| C % | 43.7 | Na % | 0.622 | Mn % | 0.013 |
| N % | 2.3 | P % | 0.65 | Cu % | 0.005 |
| C/N | 19.0 | K % | 2.8 | | |

## Results and discussion

Table (3) shows that adding chemical fertilization caused significant increase in plant length. The increase was positive with increasing the amount of fertilizer to the highest amount of chemical fertilizers (200 $kg.ha^{-1}$) which exceeded the length of the plant to (58.42 cm) with a percentage increase of 14.8% compared to 50 $kg.ha^{-1}$. Foliar fertilizer had no significant effect on plant height, while organic fertilizers caused significant increase in plant height to 56.35 cm compared to control treatment (53.35 cm). The interactions between the factors had a significant effect. The interaction of chemical fertilizer at the high level (200 $kg.ha^{-1}$) with the addition of organic and foliar fertilizers gave the highest length of 60.20 cm which differ significantly from most other interactions. While adding 50 $kg.ha^{-1}$ of chemical fertilizer without organic and foliar fertilizer gave the lowest length of 46.73 cm.

Table (4) shows that adding chemical fertilizer caused significant increase in plant leaves number with increasing fertilization level and the level of 200 $kg.ha^{-1}$ was exceeded and reached 44.29 compared to 50 $kg.ha^{-1}$. Foliar fertilization had no significant effect. Adding organic fertilizer caused significant effect and reaching (39.38) compared to control treatment (36.91). The interactions caused significant effect and adding (200 kg $ha^{-1}$) with organic and foliar fertilization was exceeded compared to most other interactions.

**Table 3.** Effect of chemical, organic and foliar fertilizers on potato plant length (cm)

| Foliar | Organic | Chemical Fertilizer Levels ( kg.ha$^{-1}$) | | | | Interaction of foliar* organic |
|---|---|---|---|---|---|---|
| | | 50 | 100 | 150 | 200 | |
| Without | without | 46.73 | 53.07 | 53.83 | 56.40 | 52.51 |
| | with | 52.40 | 55.87 | 57.07 | 58.93 | 56.07 |
| With | without | 49.80 | 53.27 | 55.53 | 58.13 | 54.18 |
| | with | 54.20 | 56.13 | 56.03 | 60.20 | 56.64 |
| Mean of chemical | | 50.78 | 54.58 | 55.62 | 58.42 | |
| LSD 0.05 | | organic= 2.331* | | interaction=4.661* | | 2.331* |
| **Interaction of chemical* organic fertilizers** | | | | | | |
| | | 50 | 100 | 150 | 200 | **Mean of organic** |
| without | | 49.57 | 54.47 | 55.45 | 57.67 | 54.29 |
| with | | 52.00 | 54.70 | 55.78 | 59.17 | 55.41 |
| LSD 0.05 | | 3.296* | | | | ns |
| **Interaction of chemical* foliar fertilizers** | | | | | | |
| | | 50 | 100 | 150 | 200 | **Mean of foliar** |
| without | | 48.27 | 53.17 | 54.68 | 57.27 | 53.35 |
| with | | 53.30 | 56.00 | 56.55 | 59.57 | 56.35 |
| LSD 0.05 | | 3.296* | | | | 1.648* |

**Table 4.** Effect of chemical, organic and foliar fertilizers on plant leaves number

| Foliar | Organic | Chemical fertilizer ( kg.ha$^{-1}$ ) | | | | Interaction organic*foliar |
|---|---|---|---|---|---|---|
| | | 50 | 100 | 150 | 200 | |
| without | without | 30.53 | 35.47 | 36.60 | 41.33 | 35.98 |
| | With | 31.53 | 39.60 | 38.87 | 44.37 | 38.68 |
| with | without | 31.67 | 35.60 | 41.00 | 43.10 | 37.84 |
| | With | 33.33 | 37.00 | 42.00 | 48.00 | 40.08 |
| Mean of chemical | | 31.77 | 36.92 | 39.62 | 44.29 | |
| LSD 0.05 | | chemical=2.326* | | interaction=4.625* | | 2.326* |
| **interaction of chemical * foliar fertilizer** | | | | | | |
| | | 50 | 100 | 150 | 200 | **Mean of foliar** |
| without | | 31.03 | 37.53 | 37.73 | 43.03 | 37.33 |
| With | | 32.50 | 36.30 | 41.50 | 45.55 | 38.96 |
| LSD 0.05 | | 3.290* | | | | n.s |
| **Interaction chemical * organic fertilizers** | | | | | | |
| | | 50 | 100 | 150 | 200 | **Mean of organic** |
| without | | 31.10 | 35.53 | 38.80 | 42.22 | 36.91 |
| With | | 32.43 | 38.30 | 40.43 | 46.37 | 39.38 |
| LSD 0.05 | | 2.290* | | | | 1.645* |

Table (5) showed that the addition of chemical manure increased leaf area significantly with increasing level (200 kg ha$^{-1}$) by giving the largest leaf area (5604 cm$^2$) with an increasing percentage of 49.6% compared to the level of 50 kg ha$^{-1}$). Foliar fertilizer caused a significant effect and reaching 4899 cm$^2$ compared to control treatment (4535 cm$^2$). Adding organic fertilizer caused significant increase to 4904 cm$^2$ compared to control treatment (4529 cm$^2$). The interactions caused significant effect , and chemical fertilizer 200 kg ha$^{-1}$ with foliar and organic fertilizers gave the highest leaf area (5709 cm$^2$) compared to 2847 cm$^2$ at 50 kg ha$^{-1}$ without foliar and organic fertilizers.

Table (6) shows that the addition of chemical fertilizer caused significant increase in chlorophyll content, and the level of 200 kg ha$^{-1}$ was superior by giving the highest chlorophyll content (41.35) significantly compared to 50 and 100 kg.ha$^{-1}$. Foliar and organic fertilizers had no significant effect on leaf chlorophyll content. The interactions had a significant effect on increasing chlorophyll content, and the interaction of high chemical fertilizer (200 kg ha$^{-1}$) with foliar and organic fertilizers was superior to all other interactions except 200 kg.ha-1 with foliar

fertilizer and 150 kg.ha$^{-1}$ with organic fertilizer or organic and foliar fertilizers, by giving (43.13 mg g$^{-1}$).

**Table 5.** Effect of chemical, organic and foliar fertilizers on plant leaf area (cm$^2$)

| Foliar | Organic | Chemical fertilizer ( kg.ha-1 ) | | | | Interaction organic * foliar |
|---|---|---|---|---|---|---|
| | | 50 | 100 | 150 | 200 | |
| without | without | 37.33 | 38.63 | 40.40 | 39.47 | 38.96 |
| | with | 39.03 | 39.20 | 41.50 | 41.00 | 40.18 |
| with | without | 37.63 | 38.83 | 39.90 | 41.80 | 39.54 |
| | with | 38.60 | 40.30 | 41.50 | 43.13 | 40.88 |
| Mean of A | | 38.15 | 39.24 | 40.83 | 41.35 | |
| LSD 0.05 | | interaction=4.068* | | chemical=2.034* | | n.s. |
| **Interaction of chemical * foliar fertilizers** | | | | | | |
| | | 50 | 100 | 150 | 200 | **Mean of foliar** |
| without | | 38.18 | 38.92 | 40.95 | 40.23 | 39.57 |
| with | | 38.12 | 39.57 | 40.70 | 42.47 | 40.21 |
| LSD 0.05 | | A*B=2.876* | | | | n.s. |
| **Interaction of chemical * organic fertilizers** | | | | | | |
| | | 50 | 100 | 150 | 200 | **Mean of organic** |
| without | | 37.48 | 38.73 | 40.15 | 40.63 | 39.25 |
| with | | 38.82 | 39.75 | 41.50 | 42.07 | 40.53 |
| LSD 0.05 | | A*C=2.876* | | | | n.s. |

**Table 6.** Effect of chemical, organic and foliar fertilizers on chlorophyll (mg.g$^{-1}$)

| Foliar | Organic | Chemical fertilizer ( kg.ha$^{-1}$ ) | | | | Interaction organic * foliar |
|---|---|---|---|---|---|---|
| | | 50 | 100 | 150 | 200 | |
| without | without | 2847 | 4165 | 4819 | 5431 | 4613 |
| | with | 3719 | 4380 | 5195 | 5720 | 4754 |
| with | without | 4028 | 4285 | 5104 | 5554 | 4743 |
| | with | 4390 | 4637 | 5484 | 5709 | 5055 |
| Mean of chemical | | 3746 | 4367 | 5151 | 5604 | |
| LSD 0.05 | | chemical=300.3* | | interaction=607.7* | | B * C=300.3* |
| **Interaction of chemical * foliar** | | | | | | |
| | | 50 | 100 | 150 | 200 | Mean of B |
| without | | 3283 | 4272 | 5007 | 5576 | 4535 |
| with | | 4209 | 4461 | 5294 | 5714 | 4899 |
| LSD 0.05 | | A*B=424.7* | | | | B=212.4* |
| **Interaction of chemical * organic** | | | | | | |
| | | 50 | 100 | 150 | 200 | Mean of C |
| without | | 3438 | 4225 | 4962 | 5493 | 4529 |
| with | | 4054 | 4508 | 5340 | 5714 | 4904 |
| LSD 0.05 | | A*c=424.7* | | | | C=212.4* |

The above results (Tables 3, 4, 5 and 6) showed that the addition of organic and chemical fertilizers caused an increase in plant growth by increasing the availability of plant nutrients and proportion C\N (Malik et al., 2011). Organic matter plays an important role in the soil ecosystems and improves most soil characteristics. It affects the physical, chemical and biological properties of the soil as well as the contribution of organic matter to the processing of various nutrients as an essential source of essential carbon for metabolic events (Valarini et al., 2009). Organic matter plays an important role in the chemical behavior of many elements in the soil through their effective aggregates (vulvic and humic acids), which have the ability to retain mineral elements in soil complexes in an chelated form (Anant-Bahadure et al., 2006), thus increasing plant vegetative growth by improving soil fertility and increased nutrient availability (Al-Obeidi,

2008). The speed of chemical fertilizers solubility leads to their availability in the soil and ready to be absorbed by the plant (Saunders, 2001).

**Table 7.** Effect chemical, foliar and organic fertilizers on tuber yield (ton $ha^{-1}$)

| Foliar | Organic | Chemical fertilizer ( $kg.ha^{-1}$ ) | | | | Interaction organic * foliar |
|---|---|---|---|---|---|---|
| | | 50 | 100 | 150 | 200 | |
| without | without | 1.377 | 1.757 | 2.093 | 2.027 | 1.813 |
| | with | 1.560 | 2.017 | 1.067 | 2.207 | 1.963 |
| with | without | 1.730 | 1.803 | 1.950 | 2.207 | 1.923 |
| | with | 1.817 | 2.137 | 2.103 | 2.377 | 2.108 |
| Mean of chemical | | 1.621 | 1.928 | 2.053 | 2.204 | |
| LSD 0.05 | | chemical=0.100* | | interaction= 0.201* | | 0.100* |
| **Interaction of chemical * foliar fertilizers** | | | | | | |
| | | 50 | 100 | 150 | 200 | Mean of foliar |
| $B_1$ | | 1.468 | 1.887 | 2.080 | 2.117 | 1.888 |
| $B_2$ | | 1.773 | 1.970 | 2.027 | 2.292 | 2.015 |
| LSD 0.05 | | 0.142* | | | | 0.071* |
| **Interaction of chemical * organic fertilizers** | | | | | | |
| | | 50 | 100 | 150 | 200 | Mean of organic |
| $C_1$ | | 1.553 | 1.780 | 2.022 | 2.117 | 1.868 |
| $C_2$ | | 1.688 | 2.077 | 2.085 | 2.292 | 2.035 |
| LSD 0.05 | | 0.143* | | | | 0.071* |

Table 7 shows that increasing chemical fertilizers led to a significant increase of tuber yield. The level of 200 kg $ha^{-1}$ achieved the largest yield of 30.31 tons $ha^{-1}$ compared to level of 50 kg $ha^{-1}$, which gave 24.77 tons. The level 100 kg $ha^{-1}$ achieved 28.51 tons $ha^{-1}$. This is due to the role of chemical fertilizers in increasing the process of photosynthesis and the transfer of manufactured materials to the tubers, which during the development stage become one of the most carbohydrate storage parts in the plant (Al-Fadhli, 2006). Foliar fertilizers significantly increased tuber yield to 29.03 tons $ha^{-1}$ compared to control (27.33 tons $ha^{-1}$). This is due to that the fertilizer providing ready and fast nutrients, and the role of potassium in the movement of carbohydrates from the source to the sink as well as the role of potassium in increasing the activity of Starch synthetase enzyme (Wang et al., 2013), which reflected in increasing tuber yield. As well as nitrogen efficiency was increased as potassium amount was available (Havlin et al., 2005). Organic fertilizers caused significant effect by increasing tuber yield to 28.71 tons $ha^{-1}$ compared to the control treatment, which achieved 27.65 tons $ha^{-1}$. This may be due to the role of organic fertilizers as an important source for nutrient supply to soil and plant, as well as increasing the activity of soil microbiology that encourages biological and enzymatic activity which reflected in the nutritional status of the plant (Agbede et al., 2008). The interactions caused a significant effect in increasing tuber yield.

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