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**RESEARCH ARTICLE**

# THE COMBINED EFFECT OF DIFFERENT FERTILIZER SOURCES AND IRRIGATION METHOD ON POTATO AND WATER PRODUCTIVITIES UNDER IRAQI CONDITIONS

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**ABSTRACT**

Three field experiments were conducted at Babylon Governorate in silty clay loam soil to investigate effects of integrated application of mineral , organic ,and bio fertilizers on yield of potato (*Solanum tuberosum* L ), and water productivity under different irrigation systems (furrow , sprinkler , and drip irrigation systems). Levels of mineral fertilizer applied included 3 levels of mineral fertilizer : 0, 50, and 100% of recommended NP fertilizer ( 300 Kg N + 100 Kg P $ha^{-1}$ ) using urea phosphate (17.5-44-0).Potassium fertilizer applied in a rate of 200 Kg K $ha^{-1}$ using (10-10-40) to all treatments. Methods of fertilizer applications were band, foliar and ferigation for furrow, sprinkler, and drip irrigation systems. Rates of organic were 0 and 10 Mg $ha^{-1}$(using organo fert.) and bio fertilizers were 0 and 950 Kg $ha^{-1}$ of (Almuaffer-bio-Egyptian source).

Results indicated that, the application of 100% of mineral fertilizer (as main effect) increased potato tuber fresh yield from 23.4 to 32.39, from 24.42 to 35.98 and from 27.46 to 40.96 Mg $ha^{-1}$ with an increment of 38%, 47% and 49% compared to that of control for furrow, sprinkler, and drip irrigation experiments, respectively. Water productivities were 7.17, 10.81, 24.39 Kg tuber yield $m^{-3}$ water applied for furrow, sprinkler, and drip irrigation experiments, respectively. Integrated application of mineral, organic and bio fertilizers gave the best results on all tested parameters. Tuber yield were 39.46 ,44.16 ,49.16 Mg $ha^{-1}$ and the best WUE in values of 9.12 , 13.27 , and 29.55 Kg yield $m^{-3}$ water applied for furrow, sprinkler , and drip irrigation experiments ,respectively. Organic fertilizer application (as single effect) gave tuber yield equal to that of 100% mineral fertilizer while bio fertilizer gave yield equal to 50% of mineral fertilizer. These results indicate that application of bio or organic fertilizers (environmentally secured sources) can substitute partially or totally mineral fertilizer.



## INTRODUCTION

The challenge facing the specialists in agricultures and farmers is the proper identification of all yield limiting factors and use the best management practices to increase the crop productivity. Fertilizer application in a proper amount and timing can be consider one of the main ways to achieve this goal (Havlin *et al*, 2005). However, unwise mineral fertilizer applications can lead to adverse effect on environment, and this lead to the necessity to reduce this application through balanced nutrient application and adaptation of bio and organic fertilizers applications for higher yield and safe environment. Optimizing fertilizer N management in potato production by taking into account N mineralization will not only protect against excessive N losses to the environment, but will also improve agronomic performance (Zebarth and Rosen, 2007). Excessive N fertilization can delay tuber growth, reduce tuber yields, lower tuber specific gravity, and adversely affect tuber storability and quality (Griffin and Hesterman, 1991).The economic pressure on the potato industry has resulted in a higher intensity of potato production. The intensive potato production system is characterized by extensive use of mineral fertilizers and increased frequency of potato in crop rotations (Stark and Porter, 2005). Several management tools have been suggested for improving potato crop performance and quality while improving soil quality characteristics such as active and stable soil organic-C and -N fractions. The most common practices recommended for potato production systems include application of compost or other organic amendments (Mallory and Griffin, 2007; Mallory and Porter, 2007). The increased soil N mineralization potential can lead to higher soil N supply and subsequently reduce the need for fertilizer N (Snapp and Fortuna, 2003). Horneck and Rosen,(2008) indicated that for potatoes, timing of nutrient application can be a challenge. Potatoes require an optimal supply of nutrients throughout the growing season to sustain their growth and tuber development. Their exact nutrient demand is a function of many factors such as the growth rate, the growth stage, the climatic conditions, and the potato variety. Additional factors such as yield goals, economic return, and environmental impacts also need to be

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considered. Since either deficient or excessive plant nutrition can reduce tuber bulking and quality, fertilizer management must be done with care.

Microbial processes in soil are important for the distribution of P between various inorganic and organic P fractions and subsequently for the potential availability of phosphate for plant acquisition. Microorganisms that interact with plant roots and their associated processes within the rhizosphere are of particular importance. Microbial influences on the availability and uptake of P by soil-grown plants are of both direct and indirect nature. Indirect effects of microorganisms on P uptake include the transfer of P from poorly available forms into plant-available forms, either by the release of metabolites, which influence solubilization or mineralization processes or by the release of accumulated P from the turnover of the soil microbial biomass. These processes are predominantly manifest within the rhizosphere where readily-available C substrates are most abundant (Jacobson, *et al* .2005). Mahmoud & Mohaned (2008) indicated that bio fertilizer application had a good effect on crop productivity.

Irrigation method especially micro-irrigation and fertigation can have an important role in water productivity and fertilizer use efficiency (Phene, 1977; Schwankl *et al*, 1998). A study was aimed to determine the effect of different irrigation methods and irrigation regimens on potato yield in the Trakya Region, Turkey, during 2003 and 2005. Potato was grown under furrow and drip irrigation methods and three regimens: irrigation applied when 30, 50, or70% of the available water was consumed. Water use efficiency values increased from 4.70 to 6.63 kg $m^{-3}$ for furrow-irrigated treatments, and from 5.19 to 9.47 kg $m^{-3}$ for drip-irrigated treatments(Erdem, *et al* .,2006).

The integrated or combined mineral-organic –bio fertilization can be consider as a management practice for balanced and sustainable nutrient supplying power and higher sustainable crop productivity (Chen, 2006) .The adoption of such system can improve crop quality and potentially reduce the risk of environmental pollution which can be associated with over mineral fertilizer applications (Al-Khalil and Ali, 2009). Olivera, *et al*.(2010) indicated that organic manure and biofertilizer gave good results with sweet potato .

Production of potato (*Solanum tuberosum* L.) takes a very important place in world agriculture, with a production potential of about 327 million mt harvested and 18.6 million ha planted area (FAO, 2004).

Therefore, the study aimed to investigate the role of bio, organic and mineral fertilizers amount and method of application on potato productivity under different water and irrigation regimes. The role of bio and organic fertilizers on substituting mineral fertilizer application with lower or no environmental risks, were investigated as well.

## MATERIALS AND METHODS

Three field experiments were conducted at Babylon Governorate in silty clay loam(table 1) to investigate effects of integrated application of mineral , organic ,and bio fertilizers on yield of potato (*Solanum tuberosum* L ), and water productivity under different irrigation systems(furrow, sprinkler , and drip irrigation systems) using split plot design for each trial . Levels of mineral fertilizer applied included 3 levels of 0,50,and 100% of (300 Kg N $ha^{-1}$ and 100 Kg P $ha^{-1}$ ) using urea phosphate (17.5-44-0).Potassium fertilizer applied in a rate of 200 Kg K $ha^{-1}$ using (10N-10$P_2O_5$-40$K_2O$ ) to all treatments.

**Table1** Some soil physical, chemical properties of trials soil

| Property | Value | Unit | Ref. |
|---|---|---|---|
| pH | 7.6 | -- | |
| EC(1:1) | 3.7 | $dSm^{-1}$ | Richards,1954 |
| Gypsum | 5.8 | g $.kg^{-1}$ soil | |
| CEC | 26.3 | C $mol_+$ $kg^{-1}$ soil | FAO,2007 |
| SOM | 16.0 | g.$kg^{-1}$ soil | Page *et al*.,1982 |
| Carbonate minerals | 217 | | FAO,2007 |
| Available N | 27 | mg.$kg^{-1}$ soil | Page et al.,1982 |
| Available P | 14 | | |
| Available K | 290 | | |
| sand | 120 | g.$kg^{-1}$ soil | |
| silt | 580 | | |
| clay | 300 | | Black, 1965. |
| Texture | Silty Clay Loam | | |

Mineral fertilizer applied differs according to method of irrigation. In furrow irrigation amounts of mineral fertilizer applied to soil as side dress in different splits wile with sprinkler 25% applied as foliar application and 75% to soil in splits too. With drip irrigation all mineral fertilizers were applied through drip irrigation using fertigation. Rates of organic were 0 and 10 Mg $ha^{-1}$(using Organo fert.) (Table 2 ) and bio fertilizers were 0 and 950 Kg $ha^{-1}$ of (Almuuffer - Bio)(table 2).all required amount applied as side dressed before planting . Sayim micro irrigation system was implemented in the sprinkler irrigation trial and T type drip irrigation was used with drip irrigation .Amount of water were measured according to soil available water and crop consumptive use. All required management practices for land preparation, plants care and weeding were done as required. Tuber total yield and water productivity were measured at tuber harvest.

**Table 2** Analysis of fertilizers used

- Urea Phosphate "UP":100% Water soluble ,17.5%N,44% $P_2O_5$
- Organo fert: decomposed, OM =%65, N%=2.5,P% = 0.44, *K%* =*1.4%*K, and C/N=16.
- Almuuffer -Bio : a mixture of *Azotobactor* spp + *Bacillus polymyxa*

## RESULTS AND DISCUSSION

Results displayed on table 3 indicated that mineral fertilizer application (as main effect) significantly increased total tuber yield from 23.40 Mg $ha^{-1}$ for control treatment to 32.39 Mg $ha^{-1}$ for b100% mineral fertilizer applied with an increment of 38.4% .Organic fertilizer application increased potato tuber yield from 19.93 (without organic) to 31.14 Mg $ha^{-1}$ (with organic) giving An increase of 56% .Bio fertilizer application gave similar response with an increase of 33%. From Table 3 we can see that organic fertilizer application can give yield

similar to that of mineral fertilizer and this mean that organic fertilization (a safe and natural product) can achieved results similar to that of mineral fertilizer under similar conditions. These results were similar to Oliveira, *et al*.(2010) results on sweet potato . Similarly, bio fertilization (a safe and natural product, too) can substitute half of mineral fertilizer.

**Table 3** impact of mineral-organic and bio fertilization on total tuber yield ($Mg.ha^{-1}$) under furrow irrigation system

| Mineral fertilizer | Bio-Organic fertilizer | | | | X |
|---|---|---|---|---|---|
| | Without | Org. | Bio | Bio+ Org. | |
| 0% PN | 14.83 | 26.12 | 21.37 | 31.29 | 23.40 |
| 50% PN | 20.67 | 31.54 | 28.08 | 36.16 | 29.11 |
| 100% PN | 24.30 | 35.75 | 30.04 | 39.46 | 32.39 |
| X | 19.93 | 31.14 | 26.50 | 35.64 | 28.30 |
| LSD 0.05 : A=1.42 ,B=1.51 ,& A x B=2.54 | | | | | |

Results on table 4 for sprinkler irrigation indicated that 100% of mineral fertilizer application increased total tuber yield by 47.3% compared to that of control .organic and bio fertilizer applications increased total tuber yield by 50% and 29% compared to that of unfertilized treatments respectively. The ability of organic and bio fertilization in partly or fully substituting mineral fertilizer can be seen in table 4, too.

**Table 4** impact of mineral-organic and bio fertilization on total tuber yield ($Mg.ha^{-1}$) under sprinkler irrigation system

| Mineral fertilizer | Bio-Organic fertilizer | | | | X |
|---|---|---|---|---|---|
| | Without | Org. | Bio | Bio+ Org. | |
| 0% PN | 15.12 | 27.04 | 22.62 | 32.87 | 24.42 |
| 50% PN | 23.33 | 33.12 | 29.87 | 37.79 | 31.03 |
| 100% PN | 27.62 | 39.16 | 32.96 | 44.16 | 35.98 |
| X | 22.03 | 33.11 | 28.48 | 38.28 | 30.48 |
| LSD 0.05 : A=1.20 ,B=1.42 ,& A x B=2.33 | | | | | |

Results on Table 5 under drip irrigation indicated that the results were at the magnitude and trend to that of furrow (Table 3) and sprinkler (Table 4) but with higher percents of increase to that of control.

**Table 5** Impact of mineral-organic and bio fertilization on total tuber yield under Drip irrigation system.

| Mineral fertilizer | Bio-Organic fertilizer | | | | X |
|---|---|---|---|---|---|
| | Without | Org. | Bio | Bio+ Org. | |
| 0% PN | 16.83 | 31.08 | 26.08 | 35.83 | 27.46 |
| 50% PN | 28.50 | 38.41 | 34.79 | 42.79 | 36.12 |
| 100% PN | 32.29 | 44.21 | 38.16 | 49.16 | 40.96 |
| X | 25.87 | 37.90 | 33.01 | 42.60 | 34.85 |
| LSD 0.05 : A=1.64 ,B=1.05 ,& A x B=2.11 | | | | | |

The impact of different fertilizers applications on water productivity for furrow, sprinkler, and drip irrigation systems were presented at tables 6, 7, and 8 .These results indicated that different rates and sources of fertilizers improved water productivity due to improvement observed in total tuber yield (tables 3, 4, and 5) and improved water consumption.

**Table 6** impact of mineral-organic and bio fertilization on water productivity ($Kg.\ m^{-3}$) under sprinkler irrigation system

| Mineral fertilizer | Bio-Organic fertilizer | | | | X |
|---|---|---|---|---|---|
| | Without | Org. | Bio | Bio+ Org. | |
| 0% PN | 4.55 | 8.12 | 6.80 | 9.88 | 7.34 |
| 50% PN | 6.87 | 9.95 | 8.97 | 11.36 | 9.29 |
| 100% PN | 8.30 | 11.77 | 9.91 | 13.27 | 10.81 |
| X | 6.57 | 9.95 | 8.56 | 11.50 | 9.14 |
| LSD 0.05 : A=0.36 ,B=0.43 ,& A x B=0.7 | | | | | |

**Table7 –**impact of mineral-organic and bio fertilization on water productivity under drip irrigation system

| Mineral fertilizer | Bio-Organic fertilizer | | | | X |
|---|---|---|---|---|---|
| | Without | Org. | Bio | Bio+ Org. | |
| 0% PN | 10.11 | 18.68 | 15.68 | 21.54 | 16.50 |
| 50% PN | 17.13 | 23.09 | 20.91 | 25.72 | 21.71 |
| 100% PN | 19.41 | 25.67 | 22.94 | 29.55 | 24.39 |
| X | 15.55 | 22.48 | 19.84 | 25.60 | 20.87 |
| LSD 0.05 : A=1.14 ,B=0.7 ,& A x B=1.43 | | | | | |

The response of potato to mineral fertilization is in the same manner to that of other trials on potato in different Iraqi soils (Abdul-Rasoul,2007 and A l-Fadlly ,2011),especially under drip irrigation (Table 8).

**Table 8** Combined analysis for some yield and productivity parameters

| Parameter | treatment | Method of irrigation and fertilizer application | | |
|---|---|---|---|---|
| | | Furrow irrigation (soil application) | Micro-sprinkler (25%foliar+75%soil applied) | Drip irrigation (fertilgation) |
| Tuber yield ($Mg.ha^{-1}$) | 100%mineral +org.+bio | 39.5 | 44.2 | 49.2 |

Results of organic fertilizers can be understood due to the role of organic fertilizers on improving physical, chemical, and biological soil properties.

The response to bio fertilizer can be due to its role in nitrogen fixation, phosphate dissolving (Table, 2) and release of some hormones, and growth regulators (Datta *et al*., 2009 ).

It can be concluded that good potato productivity can be achieved through adoption of combined fertilization and good irrigation management especially with drip irrigation (Table 9).

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