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# STUDIES ON BIO AND CHEMICAL FERTILIZATION ON SWEET POTATO (*Ipomea batatas, L)*
# 1-EFFECT OF SOME CHEMICAL NITROGEN SOURCES, RATES AND BIOFERTILIZER (NITROBIEN) ON PLANT GROWTH, YIELD AND QUALITY OF TUBER ROOTS

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## ABSTRACT

This work was conducted on sweet potato cv. 93 to evaluate the effect of Ca $(NO_3)_2$ and $(NH_4)_2 SO_4$ fertilizers as chemical N-sources in different rates either single or with biofertilizer (nitrobien) on the plant growth, yield and its components .

The obtained results could be summarized as follows:

1. Application of Ca $(NO_3)_2$ fertilizer significantly increased most studied characteristics of plant vegetative growth, non-marketable yield as compared with $(NH_4)_2 SO_4$ fertilizer. In contrast, $(NH_4)_2 SO_4$ fertilizer application was generally more useful than Ca $(NO_3)_2$ fertilizer for sweet potato production, it exerts, significant increases on total yield, marketable yield and plant yield (weight and number).
2. Inoculation of plants with biofertilizer (nitrobien) led to increase plant vegetative growth characteristics, tuber root yield and its components and beside that significantly reduced non-marketable yield comparing with the uninoculated ones.
3. Raising nitrogen fertilizer levels from 0 to 80 kg N/fed resulted in a significant increase in all studied characteristics of plant vegetative growth, total and marketable yield.
4. In general, the positive interactions between N.-sources and biofertilizer (nitrobien) have often been observed. Aplication of Ca $(NO_3)_2$ fertilizer with biofertilizer gave the highest values of plant vegetative growth, while the greatest values of tuber root yield and its components were obtained by using $(NH_4)_2 SO_4$ fertilizer with biofertilizer.
5. The interaction between nitrogen fertilizer levels and biofertilizer had a significant effect on all studied characteristics of vegetative growth, with exception of number branches /plant. It also had a significant effect on total and marketable yield. Inoculation of sweet potato plants cv. A 93 and adding 60 kg N/fed in form of $(NH_4)_2 SO_4$ achieved great yield were nearly indentical for those produced by 80 kg N/fed without biofertilizer.

Therefore, application of $(NH_4)_2 SO_4$ fertlizer as a N-source at 60 kg N/fed to sweet potato plants cv A- 93 and inoculation of plants with biofertilizer (nitrobien) are the recommended treatments for raising productivity and improving quality of tuber roots.

## INTRODUCTION

Tuber root yield of sweet potato is the integrate effect of many factors that influence the plant growth throughout the growth period. N-sources are among the major factors affecting plant growth and tuber yield of sweet potato

(Prasad, 1989). Up to now a great number of investigations have been carried out to explain the effect of N-sources on growth and productivity of many plant species including sweet potato crop. Hageman (1984) indicated that most cultivars of sweet potato were generally differed in growth and yield when supplied with $NO_3$ or $NH_4$ as a sole source of N. Several workers mentioned that $NO_3$- N may encourage sweet potato plant growth at the expense of tuber root formation, while $NH_4$ –N stimulate tuber root growth (Lorenz, 1978; Mehta and Sinha, 1983; Bundy *et al*., 1986 and El-Gamiely *et al*., 1996).

The applied N-rates is one of the major factors affecting plant growth and tuber root yields of sweet potato. Numerous investigators reported that vegetative growth of sweet potato was constantly increased as the applied N-rate increased (Patil *et al*., 1992; Mortley *et al*., 1993; Nair and Nair, 1995; Osaki *et al*., 1995; Guertral and Kemble, 1997)

Regarding the effect of N-rates on tuber root yield and its components of sweet potato there were many studies indicated that most of sweet potato cultivars generally reacted adversely to excessive N-levels by yielding less than with the moderate N-leves (Mishra *et al*., 1992; Patil *et al*., 1992; Marcno and Diaz, 1994 and Lee *et al*., 1996).

On the other hand, there are great efforts have been directed to overcoming chemical fertilization problems. In this respect, utilization of biofertilizers is considered a promising alternative instead chemical fertilizers for improvement production and quality of vegetable crops (El-Haddad *et al*., 1993). Numerous investigators reported that inoculation of sweet potato plants with $N_2$-fixing bacteria (*Azospirillum or Azotobacter*) increased total and marketable yield and advanced tuber root quality (Crossman and Hill, 1987 Kandasamy *et al*., 1988; Mortley and Hill, 1990; Khasa *et al*., 1992 and Paula *et al*., 1992).

The objective of this work was to determine the effects of soil dressing with different nitrogen sources and rates either single or in combinations with biofertilizer (nitrobien), in addition to their interactions on plant growth and yield of sweet potato.

## MATERIALS AND METHODS

In the two field experiments, sweet potato plants cv. A-93 (American variety) were grown on clay loam soil at the Horticultural Research Farm of El-Bramon (Dakahliya Governorate) during the two successive summer seasons of 1998 and 1999, to study the effects of soil dressing with different nitrogen sources and rates, i.e., 0, 20, 40, 60 and 80 kg N/fed either single or in combination with biofertilizer (nitrobien) on the plant growth and yield.

A randomized samples were obtained from the experimental soils pre and 30 days post application of biofertilizer to determine the physical and chemical contents according to the standard method described by Jackson (1967).

### The experimental design and treatments:

The experimental design was spilt-split plot system with 4 replicates. The N-sources occupied the main-plots which were subdivided to 5 sub plots each contained one of the nitrogen levels, while the biofertilization treatments were assigned to the sub-sub plots. The sub-sub plot area was 17.5 $m^2$ which contained 5 rows, 5 m length and 0.7 m width. The different nitrogen fertilizer rates in the form of ammonium sulphate (20.5 % N) and calcium nitrate (15.5 % N) were applied in two equal doses 30 and 45 days after transplanting. While biofertilizer[1] (nitrobien) was supplied at 3 kg/fed mixed with wet soft sand (1: 10 ratio) into the root absorption zone of plants after 15 days from transplanting.

**Cultural practices:**

The normal cultural practices for sweet potato commercial production were followed according to the instruction laid down by the ministry of Agriculture (Egypt). The planting date was during the third week of April, in both seasons of this study. Nearly similar stem slips (cuttings), 20 cm length were manually planted on the third top of slope ridge at 25 cm apart. The harvesting times were done 160 days from transplanting in the two years.

All plants were fertilized with calcium superphosphate (15.5 % $P_2O_5$) and potassium sulphate (48 % $K_2O$) at 300 and 200 kg /fed, respectively. 50 % being applied at planting and 50 % one month later.

**Table (1): The physical and chemical analysis of the experimental soil during 1998 and 1999 seasons.**

| Physical and chemical properties | | Pre-inoculation | | Post-inoculation | |
|---|---|---|---|---|---|
| | | 1998 | 1999 | 1998 | 1999 |
| Clay | % | 61.37 | 62.21 | 61.06 | 61.97 |
| Silt | % | 19.51 | 19.35 | 20.44 | 20.23 |
| Fine sand | % | 14.17 | 13.79 | 13.04 | 12.76 |
| Coarse sand | % | 2.13 | 1.89 | 2.07 | 1.83 |
| Organic matter | % | 0.89 | 0.93 | 1.13 | 1.20 |
| $CaCO_3$ | % | 1.90 | 2.07 | 1.56 | 1.78 |
| Water holding capacity | % | 63.17 | 59.14 | 60.48 | 62.51 |
| E.C. (dsm-1 at 25°C | % | 1.27 | 1.30 | 1.25 | 1.25 |
| Total -N | % | 0.17 | 0.15 | 0.22 | 0.19 |
| Available-P | ppm | 18.69 | 20.37 | 18.88 | 19.60 |
| Exchangeable-K | ppm | 567 | 579 | 581 | 586 |
| Total soluble salts | % | 0.43 | 0.51 | 0.45 | 0.47 |
| pH (1:2.5 w/v) | % | 8.1 | 7.9 | 7.8 | 7.7 |

**-Studied characteristics:**

**1- Plant growth parameters:**

At 120 days after transplanting, a random sample (5 plants) was taken from every treatment to determine plant vegetative growth parameters:

**[1] Nitrobien is commercial name of the biofertilizer in Egypt, it was taken from General Organization for Agriculture Equalization Fund (GOAEF), Ministry of Agriculture, Egypt. It contains live cells of efficient bacteria stains for nitrogen fixation in cultivated soils. The used biofertilizer activity was tested in Laboratories of Microbiology Department Faculty of Agriculture Mansoura University.**

a- Plant length.
b- Number of branches/plant.
c- Leaf area /plant by method of Koller (1972).
d- Total chlorophyll content by method of Comar and Zscheile (1941).

Five- Shoot dry weight of plant: The leaves and stems of chosen plants were cleaned from dust and either then oven dried till constant weight at 70 °C.

**2- Yield and its components:**

At harvest, all tuber roots of plants grown in the three central rows (45 plants) of each sub plots were weighed (kg) and converted to record as:

- Total yield.
- Marketable yield (diameter of tuber roots >3 cm).
- Non marketable yield (diameter of tuber roots <3 cm).
- Plant yield as a number and weight.
- Tuber root traits: Tuber root sample (10 storage roots) were randomly chosen at harvesting from each treatments to determine tuber root traits as follows: weight, length, diameter (using Caliper) and shape (length/diameter).

The obtained results were statistically analyzed and treatment means were compared by using least significant difference (L.S.D.) as reported by Sndecor and Cochran (1980).

## RESULTS AND DISCUSSION

**1- Plant vegetative growth:**

**a-Effect of N-sources:**

Data presented in Table (2) show that application of Ca $(NO_3)_2$ fertilizer as a N-source to sweet potato plants significantly increased plant main stem length, plant leaf area and total chlorophyll content in plant leaves in both seasons, as well as shoot dry weight/plant in the second season only as compared with $(NH_4)_2$ $SO_4$ fertilizer. However, number of branches /plant was not significantly affected by N-sources in both seasons. These increases occurred on plant growth could be attributed to that, $NO_3$ -uptake by plants from the soil may be accessible than $NH_4$, this in turn, stimulate division and elongation of cells and hence plant growth (Malhi *et al*., 1988). Also, Ca ions might have great role in plant support and leaf area duration (Mehta and Sinha, 1983). The obtained results are in harmony with those of Prasad (1989) and El-Gamiely *et al*. (1996), they found that shoot growth of sweet potato plants was generally much increased with$NO_3$ -N fertilizers than with $NH_4$ -N fertilizers.

**b- Effect of biofertilizer:**

In Table (2) also, it is evident that inoculation of sweet potato plants with biofertilizer (nitrobien) significantly increased plant main length, plant leaf area, shoot dry weight/plant and total chlorophyll content in plant leaves in both seasons, as well as number of branches /plant in the first season only comparing with the uninoculated plants. It is well known that N-biofertilizers contain active bacteria which is capable to enhance plant growth by $N_2$-fixing and contributing plant growth hormones, such as gibberellins, auxins and cytokinins (Bouton *et al*., 1985 and Cacciari *et al*., 1989). Similar results were reported by Khasa *et al*. (1992) on sweet potato and Ashour *et al*. (1997) on potato, they showed that application of biofertilizers increased foliage growth of plants than with the untreated ones.

**Table (2): Vegetative growth of sweet potato as affected by N-sources; rates and biofertilizer (nitrobien) during 1998 and 1999 seasons.**

| Characters / Treatments | Main stem length (cm) | | No. of branches/ Plant | | Plant leaf area ($m^2$) | | Shoot dry Weight/plant (gm) | | Total chlorophyll (mg/L) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 |
| **N-Sources:** | | | | | | | | | | |
| $Ca(No_3)_2$ | 146.6 | 147.3 | 13.32 | 12.62 | 1.38 | 1.41 | 77.68 | 77.53 | 0.96 | 0.97 |
| $(NH_4)_2So_4$ | 144.2 | 141.9 | 13.72 | 13.35 | 1.32 | 1.33 | 73.84 | 72.32 | 0.93 | 0.91 |
| L.S.D. at 5% | 1.21 | 1.63 | N.S. | N.S. | 0.03 | 0.02 | N.S. | 1.59 | 0.02 | 0.01 |
| N-rates: | | | | | | | | | | |
| 0 kg/fed. | 134.3 | 132.9 | 11.19 | 10.12 | 1.07 | 1.04 | 40.47 | 38.13 | 0.84 | 0.82 |
| 20 kg/fed. | 140.0 | 138.6 | 12.44 | 11.81 | 1.16 | 1.17 | 69.38 | 67.56 | 0.89 | 0.88 |
| 40 kg/fed. | 145.5 | 144.6 | 13.50 | 13.37 | 1.34 | 1.34 | 78.80 | 78.75 | 0.94 | 0.95 |
| 60 kg/fed, | 150.9 | 151.2 | 14.94 | 14.12 | 1.57 | 1.64 | 92.69 | 92.56 | 1.01 | 1.00 |
| 80 kg/fed. | 156.4 | 155.3 | 15.56 | 15.50 | 1.61 | 1.66 | 97.45 | 97.62 | 1.05 | 1.04 |
| L.S.D. at 5% | 2.05 | 2.22 | 1.04 | 1.13 | 0.04 | 0.03 | 2.60 | 2.03 | 0.03 | 0.02 |
| Nitrobien: | | | | | | | | | | |
| With | 147.9 | 147.7 | 14.22 | 13.82 | 1.38 | 1.41 | 78.43 | 77.88 | 0.98 | 0.97 |
| Without | 142.8 | 141.4 | 12.82 | 12.15 | 1.33 | 1.32 | 73.08 | 71.96 | 0.92 | 0.91 |
| L.S.D. at 5% | 1.95 | 1.66 | 0.68 | N.S. | 0.02 | 0.03 | 1.42 | 1.19 | 0.03 | 0.03 |

**c- Effect of N-rates effect:**

Data presented in Table (2) indicated that increasing nitrogen rates from 0 to 80 kg /fed increased progressively and significantly plant main stem length, number of branches /plant, plant leaf area, shoot dry weight and total chlorophyll in plant leaves. These increases may be attributed to the role of N element on metabolic processes of organic compounds in plants, it is a main constituent of protein, enzymes, chlorophylls, vitamins, hormones and nuclic acids (Bourke, 1985), which play an important role in increasing cell elongation, cell division and consequently increasing vegetative growth. Similar results were reported by Sawahata (1989); Patil *et al*. (1992), Nair and Nair (1995) and Guertal and Kemble (1997).

**d- Interaction effect between N-sources and biofertilizer:**

In Table (3), data reveal that the positive interaction between N-sources and biofertilizer has often been observed on vegetative growth characteristics of sweet potato plants. In general, there were significant increases on plant main stem length, shoot dry weight /plant and total chlorophyll content in plant leaves in both seasons as a result of biofertilizer application with Ca $(NO_3)_2$ fertilizer than with $(NH_4)_2$ $SO_4$ fertilizer. However, there were no significant effects on number of branches /plant and plant leaf area in both seasons. The presented increases on plant growth may be ascribed to the beneficial effect of both biofertilizer and Ca $(NO_3)_2$ fertilizer together on absorption and efficiency of plant nutrients (Fayez *et al*., 1985). In addition, Alexander (1977) reported that presence of $NO_3$ in the soil revives of $N_2$-fixation bacteria, while presence of $NH_4$ inhibits activities of these bacteria in soil. The obtained results are in accordance with those of Paula *et al*. (1992), who found that inoculation of sweet potato plants with *Azospirillum bacteria* + mycorrhizae fungi in combination with $NO_3$ -N at 40 kg /ha increased plant growth than with the uninoculated ones and there was a more efficient assimilation for nutrients than $N_2$-fixation.

**Table (3): Vegetative growth of sweet potato as affected by the interaction of N-sources × biofertilizer (nitrobien) during 1998 and 1999 seasons.**

| Characters / Treatments | | Main stem length (cm) | | No. of branches/ Plant | | Plant leaf area ($m^2$) | | Shoot dry weight/plant (gm) | | Total chlorophyll (mg/L) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 |
| N-Sources | Nitrobien | | | | | | | | | | |
| $Ca(No_3)_2$ | With | 149.3 | 150.5 | 14.00 | 13.45 | 1.41 | 1.46 | 80.74 | 80.96 | 0.99 | 1.00 |
| | Without | 143.8 | 144.0 | 12.65 | 11.80 | 1.36 | 1.35 | 74.63 | 74.09 | 0.93 | 0.93 |
| $(NH_4)_2So_4$ | With | 146.6 | 144.9 | 14.45 | 14.20 | 1.35 | 1.36 | 76.13 | 74.81 | 0.96 | 0.94 |
| | Without | 141.9 | 138.8 | 13.00 | 12.50 | 1.30 | 1.29 | 71.54 | 69.83 | 0.90 | 0.88 |
| L.S.D. at 5% | | 2.09 | 2.28 | N.S. | N.S. | N.S. | N.S. | 2.58 | 2.39 | 0.03 | 0.04 |

**e- Interaction effect between N-rates and biofertilizer:**

The interaction between N-rates and biofertilizer (nitrobien) significantly affected all vegetative growth characteristics in both seasons except number of branches /plant as shown in Table (4). Highest values were obtained from plant received 80 kg N/ fed and inoculated with nitrobien. While the lowest values were obtained from plants left without N application or bacterial inoculation. These results are in good accordance with those reported by Mortley and Hill (1990) and Yassin *et al*. (1994).

**2- Yield and its components:**

**a- Effect of N-sources:**

Data in Table (5) indicated that application of $(NH_4)_2$ $SO_4$ fertilizer as a N-source was generally more useful than Ca $(NO_3)_2$ fertilizer for sweet potato production, it exerted significant increases on total yield by 3.00 and 12.82 % and marketable yield by 3.07 and 13.32 % in the first and second seasons, respectively. In addition, plant yield (number and weight) was significantly increased in both seasons with $(NH_4)_2$ $SO_4$ than with Ca $(NO_3)_2$ . Therefore, $(NH_4)_2$ $SO_4$ application significantly reduced non-marketable yield by 1.26 and 5.12 in the first and second seasons, respectively. These increases occurred on yield and its components may be explained on the basis that $NH_4$ -N is more efficiency than $NO_3$ -N within plants, because $NH_4$ assimilation in plant tissues could save the energy needed for $NO_3$ reduction, this energy saving was about 17 % of the plant total carbohydrate reserves (Gutschick, 1981). Besides $NH_4$ -N is less subject to loss from the soil by leaching and volatization (Zornoza *et al*., 1987). Our results were similar with those of Bundy *et al*. (1986), who showed that sweet potato plants reacted adversely to excessive of $NO_3$ -N by yielding less comparing with $NH_4$ -N.

**Table (4):Vegetative growth of sweet potato as affected by the interaction of N-rates × biofertilizer (nitrobien) during 1998 and 1999 seasons.**

| Characters | | Main stem length (cm) | | No. of branches/ plant | | Plant leaf area ($m^2$) | | Shoot dry weight/plant (gm) | | Total chlorophyll (mg/L) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Treatments | | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 |
| N-rates | Nitrobien | | | | | | | | | | |
| 0 kg/fed. | With | 137.1 | 135.7 | 11.62 | 11.12 | 1.09 | 1.06 | 41.31 | 38.99 | 0.86 | 0.85 |
| 20 kg/fed. | | 142.9 | 141.9 | 13.00 | 12.50 | 1.19 | 1.18 | 72.52 | 72.80 | 0.92 | 0.91 |
| 40 kg/fed. | | 147.2 | 147.6 | 14.37 | 14.25 | 1.36 | 1.37 | 82.32 | 82.45 | 0.98 | 0.97 |
| 60 kg/fed. | | 153.4 | 155.0 | 15.87 | 15.00 | 1.62 | 1.71 | 96.08 | 96.13 | 1.05 | 1.04 |
| 80 kg/fed. | | 159.2 | 158.2 | 16.25 | 16.25 | 1.64 | 1.72 | 99.93 | 99.05 | 1.09 | 1.07 |
| 0 kg/fed. | Without | 131.5 | 130.2 | 10.75 | 9.12 | 1.06 | 1.03 | 39.63 | 37.27 | 0.83 | 0.79 |
| 20 kg/fed. | | 137.1 | 135.4 | 11.87 | 11.12 | 1.15 | 1.14 | 66.23 | 62.32 | 0.87 | 0.84 |
| 40 kg/fed. | | 143.7 | 141.6 | 12.62 | 12.50 | 1.33 | 1.31 | 75.29 | 75.05 | 0.90 | 0.91 |
| 60 kg/fed. | | 148.4 | 147.5 | 14.00 | 13.25 | 1.52 | 1.56 | 89.30 | 88.98 | 0.97 | 0.96 |
| 80 kg/fed. | | 153.6 | 152.4 | 14.87 | 14.75 | 1.58 | 1.58 | 94.96 | 96.19 | 1.01 | 1.01 |
| L.S.D. at 5% | | 2.66 | 2.49 | N.S. | N.S. | 0.06 | 0.04 | 2.79 | 2.83 | 0.04 | 0.05 |

**b- Effect of biofertilizer:**

In Table (5), it is clear that all studied characteristics of sweet potato yield and its components, with exception of the non-marketable yield were significantly increased with biofertilizer (nitrobien) application. Total yield was increased by 3.58 and 7.74 % and marketable yield by 3.52 and 8.26% in the first and second seasons, respectively. In the same trend, plant yield as a weight was increased in both seasons, while the number was increased in the second season only. These increases may be due to one or more from following benificial effects of biofertilizer: $N_2$-fixation, production of plant promoting substances or organic acids, enhancing nutrient uptake or protection against plant pathogens (El-Haddad *et al*., 1993). The obtained results are in agreement with those of Mortley and Hill (1990), who found that total and marketable yield of sweet potato was increased with inoculation of plants with $N_2$-fixing bacteria (*Azospirillum*) at 2, 4 and 6 weeks after transplanting.

**c- Effect of N rates:**

Data in Table (5) show that irrespective of unfertilized plants, increasing the applied N-rate from 20 to 80 kg /fed significantly increased total yield, marketable yield and plant yield (weight and number) in both seasons. The yield was increased by 37.08 and 38.40 in the first and second seasons, respectively. However, non-marketable yield was significantly reduced by using 60 kg /fed comparing with other rates in both seasons. The increases in total yield and marketable due to nitrogen fertilization may be attributed to the role of nitrogen in encouraging cell elongation, cell division and consequently increasing vegetative growth (Table, 2) and activation of photosynthesis process and metabolic which reflected increases in total and marketable yield (Bourke, 1985). Similar results were reported by Singh *et al*. (1986) and Mishra *et al*. (1992).

**Table (5):Total yield and its components of sweet potato as affected by N-sources; rates and biofertilizer (nitrobien) during 1998 and 1999 seasons.**

| Characters / Treatments | Yield /fed | | | | | | Plant yield | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total (ton) | | Marketable (ton) | | Non-Marketable (kg) | | Weight (kg) | | Number | |
| | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 |
| **N-Sources:** | | | | | | | | | | |
| $Ca(No_3)_2$ | 7.00 | 6.55 | 6.84 | 6.38 | 161 | 164 | 1.03 | 1.02 | 5.05 | 4.80 |
| $(NH_4)_2So_4$ | 7.21 | 7.39 | 7.05 | 7.23 | 159 | 156 | 1.05 | 1.04 | 5.07 | 4.97 |
| L.S.D. at 5% | 0.11 | 0.17 | 0.14 | 0.11 | 1.36 | 1.43 | 0.02 | 0.01 | 0.01 | 0.08 |
| **N-rates:** | | | | | | | | | | |
| 0 kg/fed. | 3.48 | 3.69 | 3.32 | 3.53 | 162 | 163 | 0.56 | 0.54 | 4.25 | 3.81 |
| 20 kg/fed. | 6.66 | 6.50 | 6.50 | 6.34 | 161 | 163 | 1.01 | 0.98 | 4.62 | 4.31 |
| 40 kg/fed. | 7.69 | 7.51 | 7.53 | 7.35 | 162 | 157 | 1.13 | 1.12 | 4.81 | 4.94 |
| 60 kg/fed, | 8.57 | 8.25 | 8.42 | 8.09 | 152 | 156 | 1.23 | 1.23 | 5.62 | 5.50 |
| 80 kg/fed. | 9.13 | 8.90 | 8.97 | 8.74 | 162 | 161 | 1.28 | 1.27 | 6.00 | 5.87 |
| L.S.D. at 5% | 0.18 | 0.20 | 0.17 | 0.20 | 1.72 | 1.55 | 0.03 | 0.04 | 0.17 | 0.37 |
| **Nitrobien:** | | | | | | | | | | |
| With | 7.23 | 7.23 | 7.06 | 7.08 | 158 | 153 | 1.05 | 1.07 | 5.10 | 5.33 |
| Without | 6.98 | 6.71 | 6.82 | 6.54 | 162 | 167 | 1.03 | 0.99 | 5.02 | 4.44 |
| L.S.D. at 5% | 0.10 | 0.13 | 0.10 | 0.15 | 2.39 | 2.45 | 0.02 | 0.04 | N.S | 0.31 |

### d- Interaction effect between N-sources and biofertilizer:

As regards the interaction effect of N-sources and biofertilizer (nitrobien) on yield and its components of sweet potato, data in Table (6) show that total and marketable yield were significantly increased by using $(NH_4)_2$ $SO_4$ fertilizer and biofertilizer than Ca $(NO_3)_2$ fertilizer and biofertilizer, but non-marketable yield and plant yield (number and weight) were not significantly increased in both seasons. The obtained increases could be attributed to the great effect of both biofertilizer and $(NH_4)_2$ $SO_4$ fertilizer on available nutrients in the soil and hence yields increased. Similar results were reported by Crossman and Hill (1987), who found that application of $(NH_4)_2$ $SO_4$ fertilizer with $N_2$-fixing bacteria strains was better than Ca $(NO_3)_2$ fertilizer to sweet potato production.

**Table (6): Total yield and its components of sweet potato as affected by the interaction of N-sources × biofertilizer (nitrobien) during 1998 and 1999 seasons.**

| Treatments | Characters | Yield /fed | | | | | | Plant yield | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total (ton) | | Marketable (ton) | | Non-Marketable (kg) | | Weight (kg) | | Number | |
| | | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 |
| N-Sources | Nitrobien | | | | | | | | | | |
| $Ca(No_3)_2$ | With | 7.13 | 6.83 | 6.97 | 6.67 | 159 | 158 | 1.05 | 1.06 | 5.11 | 5.25 |
| | Without | 6.86 | 6.27 | 6.69 | 6.10 | 164 | 170 | 1.01 | 0.97 | 4.99 | 4.35 |
| $(NH_4)_2So_4$ | With | 7.32 | 7.63 | 7.16 | 7.48 | 157 | 147 | 1.05 | 1.07 | 5.09 | 5.42 |
| | Without | 7.1 | 7.15 | 6.94 | 6.98 | 162 | 165 | 1.04 | 1.00 | 5.06 | 4.53 |
| L.S.D. at 5% | | 0.19 | 0.22 | 0.19 | 0.21 | N.S | N.S | N.S | N.S. | N.S | N.S |

**e- Interaction effect between N-rates and biofertilizer:**

The interaction effect between N-rates and biofertilizer (Table 7) significantly affected total and marketable yield as well as plant yield as weight in both seasons. However, plants fed on 60 kg N /fed in the presence of biofertilizer achieved great yield that was nearly identical for those produced by 80 kg N /fed without biofertilizers. The obtained results were in agreement with those of Mortley and Hill (1990) and Yassin *et al*. (1994). They showed that biofertilizer application with moderate N-level may enhance tuber root growth at the expense of foliage growth.

**3- Tuber root traits:**

**a-Effect of N-sources:**

Data in Table (8) demonstrate that application of Ca $(NO_3)_2$ or $(NH_4)_2$ $SO_4$ fertilizers as N-sources to sweet potato plants had no significant effect on weight, length, diameter and shape of tuber root in both seasons. These results coincide with those of Hammett *et al*. (1984), who found that N-sources application did not reflected any significant variations on tuber root traits of sweet potato.

**b- Effect of biofertilizer:**

In Table (8), it is noticed that weight, length and diameter of tuber root were significantly increased in both seasons by using biofertilizer (nitrobien) as compared with the untreated ones, but tuber root shape was not significantly influenced in both seasons. Such results may suggest that the used biofertilizer might improved metabolic processes of plants and hence tuber root growth as reported by Mortley and Hill (1990), which found that application of $N_2$-fixing bacteria (*Azospirillum*) enhanced tuber root growth of sweet potato at the expense of foliage growth.

**Table (7): Total yield and its components of sweet potato as affected by the interaction of N-rates × biofertilizer (nitrobien) during 1998 and 1999 seasons.**

| Characters | | Yield /fed | | | | | | Plant yield | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total (ton) | | Marketable (ton) | | Non-Marketable (kg) | | Weight (kg) | | Number | |
| Treatments | | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 |
| N-rates | Nitrobien | | | | | | | | | | |
| 0 kg/fed. | With | 3.54 | 3.98 | 3.38 | 3.83 | 161 | 155 | 0.56 | 0.57 | 4.37 | 4.18 |
| 20 kg/fed. | | 6.82 | 6.89 | 6.66 | 6.74 | 159 | 155 | 1.03 | 1.05 | 4.50 | 4.62 |
| 40 kg/fed. | | 7.86 | 7.67 | 7.70 | 7.52 | 159 | 149 | 1.14 | 1.16 | 4.87 | 5.25 |
| 60 kg/fed. | | 8.78 | 8.59 | 8.63 | 8.44 | 149 | 147 | 1.24 | 1.27 | 5.87 | 6.00 |
| 80 kg/fed. | | 9.16 | 9.00 | 9.00 | 8.84 | 160 | 156 | 1.29 | 1.31 | 5.87 | 6.60 |
| 0 kg/fed. | Without | 3.42 | 3.40 | 3.26 | 3.23 | 164 | 172 | 0.55 | 0.52 | 4.12 | 3.45 |
| 20 kg/fed. | | 6.48 | 6.11 | 6.32 | 5.94 | 164 | 170 | 0.98 | 0.93 | 4.75 | 4.00 |
| 40 kg/fed. | | 7.53 | 7.35 | 7.36 | 7.18 | 166 | 165 | 1.11 | 1.07 | 4.75 | 4.62 |
| 60 kg/fed. | | 8.37 | 7.91 | 8.22 | 7.75 | 155 | 164 | 1.22 | 1.18 | 5.37 | 5.00 |
| 80 kg/fed. | | 9.10 | 8.79 | 8.94 | 8.63 | 163 | 166 | 1.27 | 1.24 | 6.12 | 5.12 |
| L.S.D. at 5% | | 0.26 | 0.27 | 0.28 | 0.27 | N.S | N.S | 0.05 | 0.08 | N.S. | 0.41 |

**c- Effect of N-rates:**

Effect of N-rates on tuber traits were presented also in Table (8). The obtained results revealed that weight, length and diameter of tuber root were increased significantly as the applied N-rate increased from 0 to 60 kg /fed. However, there were no significant differences in shape of tuber root among the applied N-rates. The obtained increases on tuber root traits as a result of increasing N-rate may be due to the positive effect of N element on plant photosynthesis process, net-assimilation rate and hence proportion of organic compounds diverted to the tuber roots.

**Table (8): Tuber root traits of sweet potato as affected by N-sources; rates and biofertilizer (nitrobien) during 1998 and 1999 seasons.**

| Characters | Tuber root traits | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Weight (gm) | | Length (cm) | | Diameter (cm) | | Shape (len./dia.) | |
| Treatments | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 |
| **N-Sources:** | | | | | | | | |
| $Ca(No_3)_2$ | 196.7 | 198.5 | 20.5 | 21.1 | 6.9 | 7.1 | 2.97 | 2.97 |
| $(NH_4)_2So_4$ | 199.9 | 202.3 | 21.2 | 22.1 | 7.1 | 7.3 | 2.99 | 3.04 |
| L.S.D. at 5% | N.S | N.S | N.S | N.S | N.S | N.S | N.S | N.S |
| **N-rates:** | | | | | | | | |
| 0 kg/fed. | 169.3 | 167.7 | 15.0 | 15.0 | 5.1 | 5.1 | 2.96 | 2.94 |
| 20 kg/fed. | 182.0 | 186.9 | 16.4 | 17.6 | 5.4 | 5.7 | 3.04 | 3.09 |
| 40 kg/fed. | 196.3 | 198.1 | 19.9 | 20.6 | 6.6 | 7.0 | 3.01 | 2.94 |
| 60 kg/fed, | 220.6 | 223.1 | 25.9 | 27.2 | 8.7 | 8.9 | 2.98 | 3.06 |
| 80 kg/fed. | 224.5 | 226.0 | 27.0 | 27.5 | 8.9 | 9.2 | 3.03 | 2.99 |
| L.S.D. at 5% | 2.30 | 1.44 | 0.38 | 0.49 | 0.20 | 0.24 | N.S | N.S |
| **Nitrobien:** | | | | | | | | |
| With | 201.4 | 204.9 | 21.3 | 22.2 | 7.1 | 7.4 | 3.00 | 3.01 |
| Without | 195.6 | 195.8 | 20.4 | 20.9 | 6.9 | 6.9 | 2.96 | 3.01 |
| L.S.D. at 5% | 2.09 | 1.29 | 0.33 | 0.41 | 0.18 | 0.22 | N.S | N.S |

These results are in agreement with those of Prasad and Rao (1986) who proved that N supply as urea at 50, 75 or 100 kg /ha to sweet potato plants gradually increased weight and diameter of tuber root. In the same trend, Patil *et al*. (1992) showed that tuber root length and weight of sweet potato were increased with increasing the supplied N- rate from 50 to 75 or up to 100 kg /ha.

**d- Interaction effect between N-sources and biofertilizer:**

Regarding the interaction effect of N-sources with biofertilizer (nitrobien) on tuber root traits, data in Table (9) show that using $(NH_4)_2$ $SO_4$ biofertilizer significantly increased weight and diameter of tuber root in both seasons, as well as tuber root length in the second season only comparing with Ca $(NO_3)_2$ fertilizer application in the presence of biofertilizer. However, tuber root shape was not significantly affected in both seasons. It is thought that, $NH_4$ –N is less subject to loss from the soil, while the rapid loss of $NO_3$ –

N by leaching and denitrfication might be the main reason of the obtained results. Our results concerted with those of Crossman and Hill (1987).

**e- Interaction effect between N-rates and biofertilizer:**

In Table (10) the obtained data show that interaction of N-rates with biofertilizer (nitrobien) had significant effects in both seasons on tuber root weight and length of sweet potato, while diameter was significantly influenced in the first season only. However, tuber root shape was not influenced in both seasons. In general plants received 60 kg N/fed in the presence of biofertilizer gave greatest values in both seasons. Irrespective of the unfertilized plants, plants received 20 kg N/fed without biofertilizer gave the lowest values in both seasons. These results are in accordance with those of Mortley and Hill (1990), who indicated that inoculation of sweet potato plants with $N_2$-fixing bacteria (*Azospirillum*) at 2, 4 and 6 weeks after transplanting in combination with 0, 40 or 80 kg N/ha increased length and weight of tuber root, which suggest that the inoculant may enhance tuber root growth at the expense of foliage growth with low to moderate N levels (40 to 80 kg N /ha).

**Table (9): Tuber root traits of sweet potato as affected by the interaction of N-sources × biofertilizer (nitrobien) during 1998 and 1999 seasons.**

| Characters | | Tuber root traits | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Weight (gm) | | Length (cm) | | Diameter (cm) | | Shape (len./dia) | |
| Treatments | | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 |
| N-Sources | Nitrobien | | | | | | | | |
| $Ca(No_3)_2$ | With | 199.7 | 202.4 | 20.9 | 21.6 | 7.0 | 7.3 | 2.99 | 2.99 |
| | Without | 194.2 | 194.5 | 20.1 | 20.5 | 6.8 | 6.8 | 2.96 | 2.99 |
| $(NH_4)_2So_4$ | With | 203.2 | 207.4 | 21.7 | 22.8 | 7.2 | 7.6 | 3.01 | 3.00 |
| | Without | 197.1 | 197.1 | 20.6 | 21.4 | 6.9 | 7.0 | 2.98 | 3.06 |
| L.S.D. at 5% | | 2.66 | 1.59 | N.S | 0.79 | N.S. | 0.28 | N.S | N.S |

**Table (10): Tuber root traits of sweet potato as affected by the interaction of N-rates × biofertilizer (nitrobien) during 1998 and 1999 seasons.**

| Characters | | Tuber root traits | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Weight (gm) | | Length (cm) | | Diameter (cm) | | Shape (len./dia) | |
| Treatments | | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 |
| **N-rates** | **Nitrobien** | | | | | | | | |
| 0 kg/fed. | With | 170.5 | 171.4 | 15.4 | 15.9 | 5.1 | 5.3 | 3.01 | 3.00 |
| 20 kg/fed. | | 185.7 | 193.6 | 16.9 | 18.4 | 5.5 | 5.8 | 3.07 | 3.17 |
| 40 kg/fed. | | 203.1 | 207.4 | 20.4 | 21.6 | 6.8 | 7.3 | 3.00 | 2.96 |
| 60 kg/fed. | | 223.1 | 226.4 | 26.9 | 27.7 | 8.9 | 9.5 | 3.02 | 2.97 |
| 80 kg/fed. | | 224.8 | 226.0 | 27.1 | 27.6 | 9.0 | 9.5 | 2.98 | 2.91 |
| 0 kg/fed. | Without | 168.1 | 164.0 | 14.9 | 14.1 | 4.9 | 4.9 | 3.04 | 2.88 |
| 20 kg/fed. | | 178.3 | 180.3 | 15.8 | 16.8 | 5.3 | 5.6 | 2.98 | 3.00 |
| 40 kg/fed. | | 189.4 | 188.9 | 19.4 | 19.6 | 6.5 | 6.7 | 2.98 | 2.92 |
| 60 kg/fed. | | 218.1 | 219.9 | 25.0 | 26.7 | 8.5 | 8.5 | 2.94 | 3.08 |
| 80 kg/fed. | | 224.3 | 226.0 | 26.9 | 27.4 | 8.9 | 8.9 | 3.02 | 3.08 |
| L.S.D. at 5% | | 2.92 | 2.39 | 0.50 | 0.93 | 0.26 | N.S | N.S | N.S |

Generally, from the results of this study, it could be concluded that application of $(NH_4)_2$ $SO_4$ fertilizer as a N-source at 60 kg N /fed to sweet potato plants cv. A-93 and inoculation of plants with biofertilizer (nitrobien) at 3 kg /fed two weeks after transplanting is the recommended treatment for raising the productivity and improving tuber root quality. In addition to, reducing environmental pollution under the local conditions.

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# دراسات على التسميد الحيوى والكيماوى فى البطاطا
## الجزء الأول: تأثير بعض مصادر ومستويات النتروجين الكيماوى والسماد الحيوى (نتروبين) على نمو النباتات والمحصول وصفات الجذور الدرنية.

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أجريت هذه الدراسة على محصول البطاطا (صنف 93) فى مزرعة بحوث البساتين بالبرامون ـ دقهلية أثناء موسمى الزراعة الصيفيين 1998 ، 1999 بهدف تقييم تأثير بعض المصادر الكيماوية للنتروجين وهى سماد نترات الكالسيوم (15.5 % نتروجين) وسماد سلفات النشادر (20.5 % نتروجين) ومستويات التسميد النتروجينى (صفر ، 20، 40، 60، 80 كجم للفدان) كل منها منفردا أو مع السماد الحيوى (نتروبين) وكذلك التفاعل بينهما على النمو الخضرى للنباتات والمحصول ومكوناته. وقد وزعت المعاملات فى قطع منشقة مرتين فى أربع مكررات . والنتائج المتحصل عليها أمكن تلخيصها فيما يلى:-

1- أدى استعمال سماد نترات الكالسيوم إلى حدوث زيادة معنوية على معظم صفات التنمو الخضرى للنباتات والمحصول غير التسويقة فى المقابل ، كان سماد سلفات النشادر بصفة عامة أكثر فائدة من سماد نترات الكالسيوم لإنتاج البطاطا ، حيث أفرز زيادات معنوية على المحصول الكلى والمحصول التسويقى وكذلك محصول النبات (وزن ـ عدد).

2- أدى تلقيح النباتات بالسماد الحيوى (نتروبين) إلى حدوث زيادات معنوية على كل قياسات النمو الخضرى للنباتات والمحصول الكلى ومكوناته. وبالإضافة لذلك خفض معنويا المحصول غير التسويقى مقارنة مع تلك المتحصل عليها من النباتات غير الملقحة (الكنترول).

3- أظهرت النتائج أن زيادة مستويات التسميد النتروجينى حتى 80 كجم للفدان أدى إلى زيادة معنوية فى جميع الصفات الخضرية كما أدى إلى زيادة معنوية فى المحصول الكلى والتسويقى.

4- بصفة عامة، التفاعلات الموجبة بين المصادر الكيماوية للنتروجين والسماد الحيوى لوحظت فى حالات كثيرة. سجل تفاعل سماد نترات الكالسيوم مع السماد الحيوى القيم العالية لقياسات النمو الخضرى للنباتات بينما أعطى تفاعل سماد سلفات النشادر مع السماد الحيوى القيم العالية للمحصول الكلى ومكوناته .

5- سجل التفاعل بين مستويات التسميد النتروجينى والحيوى تأثيرا معنويا على صفات النمو الخضرى باستثناء عدد الأفرع للنبات وكذلك المحصول الكلى والتسويقى وأدى التلقيح بالسماد الحيوى مع إضافة 60 كجم نتروجين للفدان إلى الحصول على محصول كلى يعادل الناتج من إضافة 80 كجم للفدان بدون تلقيح بالسماد الحيوى.

بناء عليه، يعتبر استعمال سماد سلفات النشادر كمصدر للنتروجين لنباتات البطاطا بمعدل 60 كجم للفدان مع تلقيح النباتات بالسماد الحيوى (نتروبين) معاملات يوصى بها لرفع الإنتاجية وتحسين جودة الجذور الدرنية.