*J. Soil Sci. and Agric. Eng., Mansoura Univ., Vol. 5 (8): 1125 - 1139, 2014*

# EFFECT OF NITROGEN FERTILIZATION AND SOME FOLIAR APPLIED MICRONUTRIENTS ON POTATO YIELD AND NITROGEN USE EFFICIENCY.

**Khafagy, E. E. E.**
**Soils, Water and Environment Res. Inst., Agric. Res. Center, Giza, Egypt.**

## ABSTRACT

Two field experiments were carried out at Batra village, Talkha district, in Dakahlia Governorate, Egypt, during the winter growing seasons of 2012/2013 and 2013/2014. The experimental design was split plot with three replications. The aim of this research was to evaluate the effect of nitrogen fertilization level, foliar spraying of mixed (Fe, Zn & Mn) and their interactions on potato crop, quality; NPK uptake and N use efficiency. The main plots were assigned for nitrogen levels (0, 150, 175, 200 and 225 kg N fed.$^{-1}$), but the sub plots were devoid for foliar mixed Fe, Zn and Mn sulfates at the ratio 2:1:1 (at the rate: 0, 1.25 & 2.5 g L$^{-1}$). Application of N-levels significantly increased average weight of tuber, total tuber yield and shoot dry yield while foliar application of Fe, Zn and Mn mixture treatments induced significant increases in both tuber and shoot yield only. The interaction effect of N level and macronutrients on the above mentioned parameters was not significant except the average weight of tuber which showed significant effect in the first season only and application of 200 kg N fed.$^{-1}$ combined with $T_3$ recorded the heaviest tubers (219.0 and 229.2g) for the first and the second seasons, respectively. Dry matter, protein and starch % in tubers were significantly affected by N levels and foliar applied micronutrients, while the interaction showed no significant effect. The uptake of N, P and K was significantly increased with increasing N-levels and micronutrient concentration while the interaction effect was not significant. The values of N utilization efficiency and N uptake efficiency were decreased with increasing of N-levels. whereas N-level of 200 kg N fed.$^{-1}$ recorded the highest percentage of N apparent recovery fraction in both seasons. The interactions between N-levels and foliar Fe, Zn and Mn treatments affected N utilization efficiency, N uptake efficiency and N apparent recovery fraction% and the highest percentage of N apparent recovery fraction were 37.13 and 40.55 % in 1$^{st}$ and 2$^{nd}$ season, respectively with the interaction of N level (175 and 200 kg N fed.$^{-1}$, respectively) and foliar Fe, Zn and Mn treatment at 1.25g L$^{-1}$.
**Keywords:** iron, zinc, manganese, nitrogen, potato, yield, NPK, uptake, efficiency.

## INTRODUCTION

Potato (*Solanum tuberisum,* L.) as a member of the family solanaceae, is one of the most important food crops all over the world including Egypt. It ranks the first export and the second vegetable crop in acreage. Potato has a high N requirement, but its recovery of fertilizer N is often quite low. Nitrogen is an indispensable elementary constituent of numerous organic compounds of general importance (amino acids, protein, and nucleic acids) and the formation of protoplasm and new cells. Meanwhile nitrogen deficiency can substantially reduce yield. Moreover, the potato is well known to have a relatively low nitrogen use efficiency ranging between

50 and 60% (Tyler *et al*., 1983). This is due to its naturally shallow and poorly developed root system compared to other main crops such as wheat, maize or sugar beet. The soil N application gave higher yield than the zero N and lower than the fertigated treatments (Mohammad *et al*., 1999). On the other hand, Nitrogen is a crucial element in the process of plant growth and development and it is also the main yield-forming element. However, numerous papers point to low effectiveness of applied nitrogen doses. In the case of potato plants, the coefficient of nitrogen utilization is on the level of 50% and is lower than in other plants (Vos, 2009). Effectiveness of fertilization diminishes with the use of growing nitrogen doses but increases when the dose is divided into pre-sowing and top decreasing (Westermann, 2005 and Ruza *et al*., 2013).

Most potato growers in Egypt tend to use a large amounts of phosphorous fertilizers more than the recommended (Nour, 1992) which affected the micronutrients availability and created a disturbance in the soil nutrient status under such conditions. Foliar application of micronutrients has been one of the approaches to achieve an improvement of the nutritional status, yield of potato end to optimize use of chemical fertilizers (Sakr, *et al*., 1989, Nofal, *et al*., 1998 and Khalifa, *et al.,* 2003).

Iron (Fe) is an essential nutrient for plant growth and development. In plant tissues, approximately 80% of Fe is found in photosynthetic cells (Adamski, *et al*., 2011). It is directly involved in photosynthesis, respiration, nitrogen fixation, hormone synthesis, and chloroplast maintenance (Hänsch, and Mendel, 2009). Trace elements are adsorbed by inorganic constituents such as iron (Fe) oxides and form complexes with organic matter (Omil, 2007). Applications of Fe at low and excess rate than those recommended are considered as inefficient because it is believed that they lead to growth inhibition, a reduced chlorophyll content (Goos, *et al*., 2004) and an inhibition of photosynthesis in plants (Nikolic, and Kastori, 2000). In spite of chlorophyll decrease, carbon assimilation is significantly affected due to poor photosynthesis efficiency under Fe stress (Li *et al*., 2002).

Zinc (Zn) is playing a main metabolically role in plants. This element partially interferes in most of the enzymes structure like, dehydrogenises, aldolase and isomerases. In production of energy and crebs cycle Zn also is effective (Alloway, 2004).

Manganese is one of the main components in structure of enzymes. These enzymes are effective in photosynthesis and other reactions and shortage of Mn cause efficiency of photosynthesis to be decreased extremely (Heckman, 2000).

Mousavi *et al*. (2007) showed that Zn and Mn application increased all plant characteristics relating to yield and quality of potato crop. These were tuber yield per plant, dry matter percentage, specific weight, protein and starch contents of the tuber. Application of Zn at 8 ppt increased yield up to 34170 kg $ha^{-1}$ which, was 25% higher compare with control, meanwhile application of Mn at 4 ppt level increased yield to 33866 kg $ha^{-1}$ which was only 15% higher than control. However application of Mn at 8 ppt decreased both quality and yield of potato tuber compare with 2 and 4 ppt. Maximum

yield (38950 kg $ha^{-1}$) was obtained at 8 ppt of Zn with 4 ppt of Mn foliar application. Fertilizers were significantly affected element percentages in tuber. Zinc increased Zn percentage and decrease phosphorus percentage in tuber. Manganese increased Mn percentage of tuber, but no significant effected on Zn, P and K in tuber. Zinc and manganese fertilizers together increased Zn and Mn percentages and decreased P percentage in tubers. Utilization of Zn and Mn in potato production caused, increases in number of potato, tubers, mean tubers weight and finally high performance and by applying ascorbic acid, Zn, Mn and other micronutrients, quality of potato tubers is increasing (Iqbal, 1995 and Mohamadi, 2000). Studies have shown that utilization of Zn and Mn in other agriculture crops such as, wheat, barley, maize and rapeseed, caused quality and quantity of these crops to be increased (Bybordy, and Malakoty, 2003). Nofal, *et al*. (2010) indicated that there was a disorder in nutrient balance. Micronutrients foliar application resulted in higher leaf content of K, Mg, Fe, Mn and Zn compared with the control. The most favorable rates of micronutrients compound were 400g $fed.^{-1}$ and 800g $fed.^{-1}$ respectively. Also, they found that as a general trend the foliar application increased macronutrients in potato tubers.

Therefore, the main objective of the present study is to evaluate the effect of nitrogen levels, foliar application of combination Fe + Zn + Mn and their interactions on potato yield, quality, NPK uptake and N fertilization efficiencies.

## MATERIALS AND METHODS

Two field experiments were conducted in a spilt plot design in Batra village, Talkha district, Dakahlia Governorate, Egypt, during the two successive growing seasons of winter 2012/2013 and 2013/2014 on potato (*Solanum tuberosum*, L.) cultivar Salany. The experimental soil was analyzed before planting, where texture of was clay loam (36.50 % sand, 29.59 % silt and 34 % clay). Saturation percentage was 64 % and bulk density was 1.27 g $cm^{-3}$. The analysis also illustrated that soil pH in 1:2.5 soil suspension was 7.8. The soil was non-saline where EC in saturated paste extract was 3 dS $m^{-1}$ (less than 4 dS $m^{-1}$). Soil organic matter content was 3.20 % and $CaCO_3$ % was 3.2 %. Soil fertility was medium where the values of available nitrogen, phosphorus and potassium were 35, 15 and 380 ppm, respectively. The previous soil analyses were carried out according to Jackson (1967).

The treatments were arranged in a split plot design with 3 replicates, whereas the plot area was 10.5 $m^2$. The five levels of nitrogen, i.e. (0, 150, 175, 200 and 225 kg N $fed.^{-1}$) were in the main plots, and the sub-plots were assigned for the three rates of foliar application of mixed sulphats of Fe, Zn, and Mn at a ratio 2:1:1 as follows, with spraying volume of 200 L $fed.^{-1}$

$T_1$: without foliar. $T_2$: 1.25 g mixed micronutrients $L^{-1}$ (which gives 175 mg Fe $L^{-1}$, 70 mg Zn $L^{-1}$ and 75 mg Mn $L^{-1}$) $T_3$: 2.5 g mixed micronutrients $L^{-1}$.(which gives 175 mg Fe $L^{-1}$, 70 mg Zn $L^{-1}$ and 75 mg Mn $L^{-1}$)

Potato was planted at 20 December 2012 and harvested at 28 April 2013 in the 1st season and at 17 December 2013 and harvested at 30 April 2014. Applications of fertilizers were as follows, the levels of nitrogen fertilizers (Ammonium Sulfate 20.5% N) were divided into two equal doses and added with the 1st and the 2nd irrigation after planting. Calcium super-phosphate fertilizer (15 % $P_2O_5$) was applied before planting at the rate of recommended doses of 75 kg $P_2O_5$.fed.$^{-1}$ for all plots. Potassium sulfate fertilizer (50 % $K_2O$) was applied at the rate of 50 kg $K_2O$ fed.$^{-1}$ for all plots, in one dose. Application of foliar treatments of Fe, Zn and Mn was done twice after 45 and 60 days from planting at the rate of 200 letter fed.$^{-1}$.

At harvest, the following parameters were recorded:

1- Shoot dry yield (kg fed.$^{-1}$) and fresh tuber yield (Mg fed.$^{-1}$). Dry matter % was determined by drying 100 g of fresh tuber at 70 $C^0$, starch % and protein % were calculated as follows.
2- Protein % = total N % in tuber x 6.25 (Ranganna, 1977).
3- Starch % = 17.457+(0.89 x (dry matter % -24) Burton (1948).

N, P and K % were determined in shoot and tuber dry matter at harvest, according to the methods described by Jackson (1967). N, P & K uptake as kg fed.$^{-1}$ in tuber and shoot were estimated:

$$Nutrient\ uptake\ (kg\ per\ fed) = \frac{Nutrient\ content\% \times Yield\ (kg\ per\ fed)}{100}$$

4- N efficiencies, the amount of nitrogen originating from mineralization for each year and experimental treatment was determined as the difference between the content of mineral nitrogen in soil before planting with nitrogen absorbed by the potato plants in the plants without fertilization (0 kg N $ha^{-1}$) and mineral nitrogen in the soil after harvest (Huggins and Pan, 1993). The following parameters were calculated for each treatment:

- N uptake efficiency ($NU_pE$; kg N-Uptake $kg^{-1}$ N-Supply) as the ratio of N uptake by plants to N supply.

$$NUpE = \frac{Total\ Nitrogen\ Uptake\ .kg}{Total\ nitrogen\ supply\ .kg}$$

- N utilization efficiency ($NU_tE$; kg- Tuber yield $kg^{-1}$-Nitrogen Uptake) as the ratio of Tuber yield dry weight of plants to N uptake.

$$NUtE = \frac{Tuber\ yield\ .kg}{Total\ nitrogen\ Uptake\ .kg}$$

- N apparent recovery fraction (NRF; %) as the percentage of (N uptake by plant at applied treatment ($N_x$ Uptake) – N uptake by plant at control treatment ($N_0$.Uptake)) from N applied at applied treatment ($N_x$.Supply).

$$NRF\% = \frac{Nx.Uptake - N0.Uptake}{Nx.Supply} \times 100$$

The statistical analysis of the obtained data was done according to the methods described by Gomez and Gomez (1984).

## RESULTS AND DISCUSSION

**Potato Yield and its components:**

Data in Table 1 show the effect of application of N-levels, foliar treatments of Fe, Zn and Mn mixture and their interactions on total tuber yield, average weight of tuber and shoot dry weight. As shown in Table 1 the addition of N-levels significantly increased total tubers yield, average weight of tuber and shoot dry weight up to $N_{200}$ in the two seasons. The highest total tubers yield was 18.213 & 18.857 Mg fed.$^{-1}$ in the 1$^{st}$ and the 2$^{nd}$ seasons, respectively. Also, average weight of tuber and shoot dry weight significantly increased with N-level up to 200 kg N fed.$^{-1}$ in both seasons. These results may be return to the low level of available N in soil before planting and to the vital role of N in plant. These results are confirmed with those obtained by Mohammad *et al*., (1999). Also, data reveal that foliar application of Fe, Zn and Mn treatments increased total tubers yield, average weight of tuber and shoot dry weight and foliar treatments of $T_2$ was more effective in both seasons, since, the differences between $T_2$ and $T_3$ were insignificant. Similar results were obtained by Mousavi *et al*., (2007) and Bybordy and Malakoty (2003).

Concerning the effect of interactions between N-levels and foliar treatments, results in table 1 illustrate that values of total tubers yield, average weight of tuber and dry shoot weight were not significantly affected by interaction except the average weight of tuber which was significantly affected in one season only and application of 200 N fed.$^{-1}$ along with foliar applied micronutrients at the rate of 2.5 g L$^{-1}$ recorded the highest value (219.0 g tuber$^{-1}$).

**Potato tubers quality:**

Data in Table 2 show that the addition of nitrogen fertilizer levels significantly decreased dry matte % in tuber when compared with control. As for protein %, it is obvious from the results that its values significantly increased with N fertilization, while starch % decreased with addition of N levels up to $N_{225}$. These results are confirmed with those obtained by Nofal, *et al*., (1998) and Khalifa *et al*. (2003).

Concerning the effect of foliar treatments, data reveal that percentages of dry matter, protein and starch significantly increased by foliar treatments $T_2$ and $T_3$ compared with $T_1$ (control). Similar results were obtained by Bybordy and Malakoty (2003).

The interaction between nitrogen levels and Fe, Zn and Mn foliar treatments insignificantly affected on dry matter %, starch % and protein% as shown in Table 2. The values of dry matter % were decreased with interactions, and the highest values of dry matter % were obtained with $N_0$*$T_3$ and $N_0$*$T_2$ in both seasons. The effect of interaction on protein % was insignificant.

**Table 1: Effect of foliar application of Fe, Zn and Mn and nitrogen levels and their interactions on potato yield.**

| Treatments | | Total tubers yield (Mg fed.$^{-1}$) | | Average weight of tuber (g) | | shoot dry weight (kg fed.$^{-1}$) | |
|---|---|---|---|---|---|---|---|
| | | 1st season | 2nd season | 1st season | 2nd season | 1st season | 2nd season |
| **Nitrogen Levels** | | | | | | | |
| $N_0$ | | 7.343 | 7.610 | 78.6 | 81.4 | 455.56 | 514.29 |
| $N_{150}$ | | 15.629 | 15.410 | 143.4 | 141.0 | 598.41 | 673.02 |
| $N_{175}$ | | 16.190 | 16.978 | 172.4 | 181.6 | 611.11 | 698.10 |
| $N_{200}$ | | 18.213 | 18.857 | 195.3 | 201.6 | 636.51 | 717.46 |
| $N_{225}$ | | 17.838 | 17.892 | 196.7 | 197.7 | 636.51 | 707.94 |
| LSD at 5% | | 1.337 | 1.398 | 19.649 | 18.900 | 16.451 | 12.453 |
| **Fe, Zn and Mn foliar treatments** | | | | | | | |
| $T_1$ | | 14.310 | 14.406 | 149.3 | 150.1 | 571.43 | 626.67 |
| $T_2$ | | 15.333 | 15.779 | 159.5 | 164.4 | 585.71 | 672.19 |
| $T_3$ | | 15.484 | 15.863 | 163.1 | 167.4 | 605.71 | 687.62 |
| LSD 5% | | 1.376 | 1.037 | Ns | Ns | 14.233 | 22.472 |
| **Interaction (Nitrogen Levels*FZM foliar)** | | | | | | | |
| $N_0$ | $T_1$ | 6.657 | 7.057 | 71.3 | 75.2 | 428.57 | 471.43 |
| | $T_2$ | 7.629 | 7.752 | 81.5 | 83.2 | 461.90 | 528.57 |
| | $T_3$ | 7.743 | 8.019 | 83.1 | 85.8 | 476.19 | 542.86 |
| $N_{150}$ | $T_1$ | 14.848 | 14.581 | 158.8 | 156.3 | 571.43 | 623.81 |
| | $T_2$ | 15.819 | 15.543 | 129.3 | 125.7 | 604.76 | 690.48 |
| | $T_3$ | 16.219 | 16.105 | 141.9 | 140.9 | 619.05 | 704.76 |
| $N_{175}$ | $T_1$ | 15.514 | 16.352 | 181.0 | 190.8 | 590.48 | 657.14 |
| | $T_2$ | 16.543 | 17.114 | 176.9 | 183.6 | 600.00 | 684.76 |
| | $T_3$ | 16.514 | 17.467 | 159.3 | 170.4 | 642.86 | 752.38 |
| $N_{200}$ | $T_1$ | 17.267 | 17.076 | 168.1 | 163.6 | 638.10 | 676.19 |
| | $T_2$ | 18.600 | 19.848 | 198.7 | 211.9 | 623.81 | 752.38 |
| | $T_3$ | 18.771 | 19.648 | 219.0 | 229.2 | 647.62 | 723.81 |
| $N_{225}$ | $T_1$ | 17.267 | 16.962 | 167.1 | 164.6 | 628.57 | 704.76 |
| | $T_2$ | 18.076 | 18.638 | 210.9 | 217.4 | 638.10 | 704.76 |
| | $T_3$ | 18.171 | 18.076 | 212.0 | 210.9 | 642.86 | 714.29 |
| LSD 5% | | Ns | Ns | 30.457 | Ns | Ns | Ns |

**Table 2: Effect of foliar application of Fe, Zn and Mn and nitrogen levels and their interactions on potato tubers quality.**

| Treatments | | Dry Matter % | | Protein % | | Starch % | |
|---|---|---|---|---|---|---|---|
| | | 1st season | 2nd season | 1st season | 2nd season | 1st season | 2nd season |
| **Nitrogen Levels** | | | | | | | |
| $N_0$ | | 20.67 | 20.68 | 12.32 | 11.99 | 14.42 | 14.43 |
| $N_{150}$ | | 20.17 | 20.24 | 14.49 | 14.94 | 13.97 | 14.03 |
| $N_{175}$ | | 19.80 | 19.49 | 14.96 | 15.24 | 13.64 | 13.37 |
| $N_{200}$ | | 19.41 | 19.38 | 15.02 | 15.33 | 13.29 | 13.27 |
| $N_{225}$ | | 19.00 | 18.98 | 15.08 | 15.55 | 12.93 | 12.91 |
| LSD 5% | | 0.417 | 0.416 | 0.388 | 0.229 | 0.371 | 0.370 |
| **Fe, Zn and Mn foliar treatments** | | | | | | | |
| $T_1$ | | 19.45 | 19.17 | 14.13 | 14.40 | 13.33 | 13.08 |
| $T_2$ | | 19.87 | 20.09 | 14.40 | 14.63 | 13.70 | 13.90 |
| $T_3$ | | 20.11 | 20.01 | 14.59 | 14.80 | 13.92 | 13.83 |
| LSD 5% | | 0.410 | 0.516 | 0.293 | 0.155 | 0.365 | 0.460 |
| **Interaction (Nitrogen Levels*FZM foliar)** | | | | | | | |
| $N_0$ | $T_1$ | 20.03 | 20.13 | 12.15 | 11.83 | 13.84 | 13.94 |
| | $T_2$ | 20.45 | 21.12 | 12.33 | 11.92 | 14.23 | 14.82 |
| | $T_3$ | 21.53 | 20.80 | 12.48 | 12.23 | 15.18 | 14.53 |
| $N_{150}$ | $T_1$ | 19.80 | 19.47 | 14.23 | 14.65 | 13.64 | 13.35 |
| | $T_2$ | 20.24 | 20.79 | 14.42 | 14.94 | 14.03 | 14.52 |
| | $T_3$ | 20.46 | 20.46 | 14.81 | 15.25 | 14.23 | 14.23 |
| $N_{175}$ | $T_1$ | 19.40 | 19.00 | 14.71 | 15.04 | 13.29 | 12.93 |
| | $T_2$ | 19.93 | 19.48 | 15.00 | 15.29 | 13.76 | 13.36 |
| | $T_3$ | 20.07 | 19.99 | 15.17 | 15.40 | 13.88 | 13.81 |
| $N_{200}$ | $T_1$ | 19.25 | 18.72 | 14.73 | 15.15 | 13.15 | 12.68 |
| | $T_2$ | 19.54 | 19.87 | 15.08 | 15.40 | 13.41 | 13.71 |
| | $T_3$ | 19.43 | 19.55 | 15.25 | 15.46 | 13.32 | 13.42 |
| $N_{225}$ | $T_1$ | 18.77 | 18.51 | 14.83 | 15.35 | 12.72 | 12.49 |
| | $T_2$ | 19.18 | 19.18 | 15.15 | 15.60 | 13.09 | 13.09 |
| | $T_3$ | 19.06 | 19.24 | 15.25 | 15.69 | 12.98 | 13.15 |
| LSD 5% | | NS | NS | NS | NS | NS | NS |

**N-Uptake (kg fed.$^{-1}$):**

Data in Table 3 reveal that application of N-levels significantly increased N-uptake by shoots, tubers yield and total uptake by potato plants. Application of $N_{225}$ recorded the highest N-uptake by shoots, while $N_{200}$ recorded the highest N-uptake by tubers yield and total uptake. These results are in accordance with those reported by Abdel-Kader (2002).

Also, results show that foliar application of Fe, Zn and Mn treatments significantly increased the uptake of N by shoot and tubers yield. Total N-uptake were increased by 10.31 and 14.05% in 1st season and by 15.54 and 17.41% in 2nd season with foliar treatments $T_2$ and $T_3$, respectively compared with $T_1$. Similar results were obtained by Nofal *et al*. (2010)

Although the interaction effect on N uptake was not significant as shown in Table 3, the values were high under N × micronutrient combinations and $N_{200}$*$T_3$ recorded the highest total N uptake (114.985 kg fed.$^{-1}$) in the first season while $N_{200}$*$T_2$ gave the highest value (125.58 kg fed.$^{-1}$) in the second season. This could be attributed to that the applied micronutrients enhanced the metabolic process via enzyme activation which in turn encourages N-uptake by plants.

**P-uptake (kg fed.$^{-1}$):**

Data in Table 4 indicate that P-uptake by shoots, tubers yield and total uptake were significantly increased with increasing N-levels, up to $N_{175}$ for P-uptake by shoots and up to $N_{200}$ for total P-uptake. The positive effect of nitrogen application on P uptake by plants could be attributed to the increasing of root growth, altered metabolism, and increased solubility of soil P. Similar results were obtained by Sakr *et al*. (1998) and Khailfa *et al*. (2003).

Data in Table 4 reveal also that foliar treatments of mixed Fe, Zn and Mn significantly was insignificant in P-uptake by potato plants (shoots, tubers or total), whereas these increases were significant up to $T_2$. These results are confirmed with those obtained by Nofal *et al*. (2010). Respecting the effect of interactions, results show that the effect of interactions between N-levels and foliar treatments was insignificant on p-uptake for shoots or tubers and the total uptake in both seasons. However, the highest total P-uptake was 15.573 and 17.659 kg fed.$^{-1}$ at the interaction $N_{200}$*$T_2$ in 1st and 2nd seasons, respectively.

**K-uptake (kg fed.$^{-1}$):**

Data presented in Table 5 show that application of N-levels significantly affected potassium uptake. The values of K-uptake significantly increased by N fertilization up to $N_{200}$ in both seasons then declined. The highest total K-uptake was 69.764 and 80.188 kg fed.$^{-1}$ in the 1st and the 2nd seasons respectively with $N_{200}$. The positive effect of nitrogen fertilization on K uptake may be related to the role of N in increasing the root and vegetative growth and consequently the uptake of nutrients. These effects are in agreement with that obtained by Nofal *et al*., (2010).

Also, data reveal that foliar treatments of mixed Fe, Zn and Mn significantly increased K-uptake by potato plants, since the highest total K-uptake was 62.320 kg fed.$^{-1}$ with $T_3$ in 1st season and 72.151 kg fed.$^{-1}$ in 2nd season with $T_3$ too. Nofal *et al*. (2010) reported similar results.

Here again, though the interaction effect was not significant as shown in Table 5, K uptake by potato plants was high by N level × micronutrient compared with the micronutrients application only and the highest total K uptake was recorded by $N_{200}$*$T_3$ (75.96 and 87.213 kg fed.$^{-1}$ during the first and second season, respectively.

**Table 3: Effect of foliar application of Fe, Zn and Mn and nitrogen levels and their interactions on N-uptake (kg fed.$^{-1}$) by potato shoots and tubers yields.**

| Treatments | | N-Uptake (kg fed.$^{-1}$) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1st season | | | 2nd season | | |
| | | Shoots | tubers | Total-uptake | Shoots | tubers | Total-uptake |
| Nitrogen Levels | | | | | | | |
| $N_0$ | | 12.804 | 30.002 | 42.806 | 12.821 | 30.248 | 43.069 |
| $N_{150}$ | | 21.208 | 73.133 | 94.341 | 21.990 | 74.869 | 96.858 |
| $N_{175}$ | | 23.544 | 76.781 | 100.324 | 25.934 | 80.762 | 106.696 |
| $N_{200}$ | | 24.913 | 85.024 | 109.937 | 27.233 | 89.751 | 116.985 |
| $N_{225}$ | | 26.240 | 81.788 | 108.029 | 28.116 | 84.540 | 112.656 |
| LSD 5% | | 3.622 | 3.859 | 3.818 | 3.822 | 6.544 | 6.177 |
| Fe, Zn and Mn foliar treatments | | | | | | | |
| $T_1$ | | 20.469 | 63.776 | 84.245 | 21.352 | 64.473 | 85.826 |
| $T_2$ | | 21.847 | 71.086 | 92.932 | 23.836 | 75.331 | 99.168 |
| $T_3$ | | 22.910 | 73.176 | 96.086 | 24.468 | 76.297 | 100.765 |
| LSD 5% | | 0.597 | 2.146 | 2.173 | 0.758 | 5.123 | 4.819 |
| Interaction (Nitrogen Levels*FZM foliar) | | | | | | | |
| $N_0$ | $T_1$ | 11.566 | 25.923 | 37.489 | 11.156 | 26.874 | 38.031 |
| | $T_2$ | 12.996 | 30.789 | 43.785 | 13.250 | 31.224 | 44.474 |
| | $T_3$ | 13.851 | 33.294 | 47.145 | 14.057 | 32.645 | 46.702 |
| $N_{150}$ | $T_1$ | 19.709 | 66.948 | 86.657 | 19.421 | 66.610 | 86.032 |
| | $T_2$ | 21.551 | 73.745 | 95.296 | 22.609 | 77.509 | 100.117 |
| | $T_3$ | 22.365 | 78.707 | 101.072 | 23.939 | 80.487 | 104.426 |
| $N_{175}$ | $T_1$ | 22.099 | 70.837 | 92.936 | 24.151 | 74.702 | 98.854 |
| | $T_2$ | 23.340 | 79.119 | 102.459 | 26.408 | 81.564 | 107.972 |
| | $T_3$ | 25.192 | 80.386 | 105.578 | 27.242 | 86.019 | 113.261 |
| $N_{200}$ | $T_1$ | 24.338 | 78.348 | 102.686 | 25.111 | 77.073 | 102.184 |
| | $T_2$ | 24.393 | 87.748 | 112.141 | 28.433 | 97.147 | 125.580 |
| | $T_3$ | 26.008 | 88.977 | 114.985 | 28.155 | 95.034 | 123.189 |
| $N_{225}$ | $T_1$ | 24.634 | 76.824 | 101.458 | 26.922 | 77.107 | 104.029 |
| | $T_2$ | 26.952 | 84.028 | 110.980 | 28.482 | 89.214 | 117.696 |
| | $T_3$ | 27.135 | 84.514 | 111.649 | 28.945 | 87.300 | 116.244 |
| LSD 5% | | NS | NS | NS | NS | NS | NS |

**Table 4: Effect of foliar application of Fe, Zn and Mn and nitrogen levels and their interactions on P-uptake by potato shoots and tubers yields.**

| Treatments | | P-Uptake (kg fed.$^{-1}$) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1st season | | | 2nd season | | |
| | | Shoots | tubers | Total-uptake | Shoots | tubers | Total-uptake |
| Nitrogen Levels | | | | | | | |
| $N_0$ | | 1.753 | 4.753 | 6.506 | 1.841 | 5.451 | 7.291 |
| $N_{150}$ | | 2.397 | 10.213 | 12.610 | 2.509 | 11.545 | 14.054 |
| $N_{175}$ | | 2.726 | 11.251 | 13.977 | 2.795 | 13.272 | 16.068 |
| $N_{200}$ | | 2.692 | 11.994 | 14.685 | 2.748 | 13.521 | 16.269 |
| $N_{225}$ | | 2.628 | 11.745 | 14.373 | 2.769 | 12.712 | 15.481 |
| LSD 5% | | 0.466 | 0.444 | 0.432 | 0.186 | 1.111 | 1.091 |
| Fe, Zn and Mn foliar treatments | | | | | | | |
| $T_1$ | | 2.316 | 9.062 | 11.378 | 2.368 | 10.075 | 12.443 |
| $T_2$ | | 2.452 | 10.326 | 12.778 | 2.603 | 11.821 | 14.424 |
| $T_3$ | | 2.550 | 10.585 | 13.136 | 2.626 | 12.005 | 14.631 |
| LSD 5% | | 0.045 | 0.475 | 0.437 | 0.103 | 0.830 | 0.829 |
| Interaction (Nitrogen Levels*FZM foliar) | | | | | | | |
| $N_0$ | $T_1$ | 1.613 | 4.139 | 5.751 | 1.693 | 4.874 | 6.567 |
| | $T_2$ | 1.737 | 4.866 | 6.603 | 1.868 | 5.574 | 7.442 |
| | $T_3$ | 1.911 | 5.254 | 7.165 | 1.962 | 5.904 | 7.866 |
| $N_{150}$ | $T_1$ | 2.190 | 9.519 | 11.709 | 2.305 | 10.015 | 12.319 |
| | $T_2$ | 2.395 | 10.318 | 12.713 | 2.578 | 11.393 | 13.971 |
| | $T_3$ | 2.607 | 10.801 | 13.408 | 2.643 | 13.229 | 15.871 |
| $N_{175}$ | $T_1$ | 2.523 | 10.059 | 12.582 | 2.609 | 12.215 | 14.823 |
| | $T_2$ | 2.746 | 11.461 | 14.207 | 2.807 | 13.751 | 16.558 |
| | $T_3$ | 2.910 | 12.233 | 15.143 | 2.970 | 13.852 | 16.822 |
| $N_{200}$ | $T_1$ | 2.660 | 10.730 | 13.391 | 2.532 | 11.574 | 14.105 |
| | $T_2$ | 2.700 | 12.873 | 15.573 | 2.918 | 14.741 | 17.659 |
| | $T_3$ | 2.714 | 12.378 | 15.092 | 2.795 | 14.250 | 17.044 |
| $N_{225}$ | $T_1$ | 2.593 | 10.865 | 13.457 | 2.702 | 11.699 | 14.401 |
| | $T_2$ | 2.682 | 12.111 | 14.793 | 2.843 | 13.647 | 16.491 |
| | $T_3$ | 2.609 | 12.260 | 14.870 | 2.761 | 12.789 | 15.550 |
| LSD 5% | | 0.100 | NS | NS | NS | NS | NS |

**Table 5: Effect of foliar application of Fe, Zn and Mn and nitrogen levels and their interactions on K-uptake by potato shoots and tubers yields.**

| Treatments | | K-Uptake (kg fed.$^{-1}$) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1st season | | | 2nd season | | |
| | | Shoots | tubers | Total-uptake | Shoots | tubers | Total-uptake |
| **Nitrogen Levels** | | | | | | | |
| $N_0$ | | 11.826 | 20.172 | 31.997 | 13.820 | 22.573 | 36.392 |
| $N_{150}$ | | 17.425 | 45.000 | 62.425 | 20.067 | 47.960 | 68.027 |
| $N_{175}$ | | 18.754 | 50.107 | 68.860 | 21.795 | 55.263 | 77.059 |
| $N_{200}$ | | 18.415 | 51.349 | 69.764 | 21.186 | 59.002 | 80.188 |
| $N_{225}$ | | 17.504 | 50.152 | 67.656 | 20.521 | 55.004 | 75.525 |
| LSD 5% | | 1.278 | 2.371 | 3.102 | 1.022 | 5.946 | 6.297 |
| **Fe, Zn and Mn foliar treatments** | | | | | | | |
| $T_1$ | | 16.161 | 39.834 | 55.995 | 18.214 | 41.948 | 60.162 |
| $T_2$ | | 16.674 | 45.432 | 62.107 | 19.989 | 50.011 | 70.001 |
| $T_3$ | | 17.519 | 44.801 | 62.320 | 20.230 | 51.922 | 72.151 |
| LSD 5% | | 0.871 | 2.691 | 3.253 | 1.024 | 3.332 | 3.513 |
| **Interaction (Nitrogen Levels*FZM foliar)** | | | | | | | |
| $N_0$ | $T_1$ | 10.560 | 17.311 | 27.871 | 12.332 | 19.932 | 32.263 |
| | $T_2$ | 12.098 | 20.590 | 32.688 | 14.231 | 23.322 | 37.553 |
| | $T_3$ | 12.819 | 22.614 | 35.433 | 14.895 | 24.466 | 39.361 |
| $N_{150}$ | $T_1$ | 16.339 | 41.083 | 57.422 | 17.852 | 41.681 | 59.532 |
| | $T_2$ | 16.535 | 45.477 | 62.012 | 20.388 | 48.914 | 69.301 |
| | $T_3$ | 19.402 | 48.440 | 67.842 | 21.961 | 53.285 | 75.246 |
| $N_{175}$ | $T_1$ | 18.634 | 45.406 | 64.040 | 20.855 | 50.676 | 71.531 |
| | $T_2$ | 18.362 | 51.094 | 69.456 | 21.202 | 55.003 | 76.205 |
| | $T_3$ | 19.265 | 53.820 | 73.085 | 23.330 | 60.111 | 83.440 |
| $N_{200}$ | $T_1$ | 18.521 | 46.168 | 64.689 | 20.760 | 47.255 | 68.015 |
| | $T_2$ | 18.276 | 57.684 | 75.960 | 22.159 | 65.054 | 87.213 |
| | $T_3$ | 18.448 | 50.194 | 68.643 | 20.639 | 64.697 | 85.335 |
| $N_{225}$ | $T_1$ | 16.752 | 49.203 | 65.955 | 19.272 | 50.199 | 69.471 |
| | $T_2$ | 18.099 | 52.318 | 70.417 | 21.967 | 57.763 | 79.730 |
| | $T_3$ | 17.660 | 48.937 | 66.596 | 20.323 | 57.050 | 77.373 |
| LSD 5% | | NS | NS | NS | NS | NS | NS |

**N fertilization efficiencies:**

Nitrogen use efficiency can be defined as the maximum economic yield produced per unit of nutrient applied, absorbed or utilized by the plant to produce grain and straw (Fageria, and Baligar, 2001). However, in the literature, nutrient use efficiency has been defined in several ways including. Apparent recovery, nutrient uptake efficiency and nutrient utilization efficiency. In field studies, nutrient use efficiencies are either calculated based on differences in crop yield and/or nutrient uptake between fertilized plots and unfertilized control or by using isotop-labled fertilizers to estimate crop and soil recovery of applied nutrients.

Data presented in Table 6 show the effects of application N-levels and their interactions with foliar treatments of mixed Fe, Zn and Mn on N utilization efficiency ($NU_tE$), (kg tubers yield kg total N-uptake$^{-1}$), N-uptake efficiency ($NU_pE$) (kg N-uptake kg N-Supply$^{-1}$) and N apparent recovery fraction percentage (NRF %) for potato plants in two seasons.

**Table 6: Effect of foliar application of Fe, Zn and Mn and nitrogen levels and their interactions on some indices of nitrogen use efficiencies of potato yield.**

| Treatments | | N Utilization Efficiency $NU_tE$ kg yield kg N-uptake$^{-1}$ | | N Uptake Efficiency $NU_pE$ kg N-uptake kg N-supply$^{-1}$ | | N Apparent Recovery Fraction NRF % | |
|---|---|---|---|---|---|---|---|
| | | 1st season | 2nd season | 1st season | 2nd season | 1st season | 2nd season |
| **Nitrogen Levels** | | | | | | | |
| $N_0$ | | 171.536 | 176.683 | 0.000 | 0.000 | 0.00 | 0.00 |
| $N_{150}$ | | 165.660 | 159.093 | 0.629 | 0.646 | 34.36 | 35.86 |
| $N_{175}$ | | 161.381 | 159.124 | 0.573 | 0.610 | 32.87 | 36.36 |
| $N_{200}$ | | 165.664 | 161.193 | 0.550 | 0.585 | 33.57 | 36.96 |
| $N_{225}$ | | 165.123 | 158.820 | 0.432 | 0.451 | 26.09 | 27.84 |
| Mean | | 165.873 | 162.983 | 0.437 | 0.458 | 25.38 | 27.40 |
| **Interaction (Nitrogen Levels*FZM foliar)** | | | | | | | |
| $N_0$ | $T_1$ | 177.575 | 185.565 | 0.000 | 0.000 | 0.00 | 0.00 |
| | $T_2$ | 174.228 | 174.312 | 0.000 | 0.000 | 0.00 | 0.00 |
| | $T_3$ | 164.235 | 171.707 | 0.000 | 0.000 | 0.00 | 0.00 |
| $N_{150}$ | $T_1$ | 171.338 | 169.483 | 0.578 | 0.574 | 32.78 | 32.00 |
| | $T_2$ | 166.000 | 155.246 | 0.635 | 0.667 | 34.34 | 37.10 |
| | $T_3$ | 160.470 | 154.222 | 0.674 | 0.696 | 35.95 | 38.48 |
| $N_{175}$ | $T_1$ | 166.936 | 165.420 | 0.531 | 0.565 | 31.68 | 34.76 |
| | $T_2$ | 161.458 | 158.507 | 0.585 | 0.617 | 37.13 | 36.28 |
| | $T_3$ | 156.418 | 154.216 | 0.603 | 0.647 | 33.39 | 38.03 |
| $N_{200}$ | $T_1$ | 168.150 | 167.112 | 0.513 | 0.511 | 32.60 | 32.08 |
| | $T_2$ | 165.862 | 158.047 | 0.561 | 0.628 | 34.18 | 40.55 |
| | $T_3$ | 163.251 | 159.491 | 0.575 | 0.616 | 33.92 | 38.24 |
| $N_{225}$ | $T_1$ | 170.185 | 163.050 | 0.406 | 0.416 | 25.59 | 26.40 |
| | $T_2$ | 162.878 | 158.358 | 0.444 | 0.471 | 26.88 | 29.29 |
| | $T_3$ | 162.756 | 155.502 | 0.447 | 0.465 | 25.80 | 27.82 |
| Mean | | 166.116 | 163.349 | 0.437 | 0.458 | 25.62 | 27.40 |

It is obvious from the results in Table 6 that values of $NU_tE$ and $NU_pE$ were decreased with increasing N-levels, and $N_{200}$ recorded the highest percentage of NRF% (36.96 %) in 2nd season. Also, data illustrate that interactions between N-levels and foliar treatments affected $NU_tE$, $NU_pE$ and NRF %, since the highest percentage of NRF% were 37.13 and 40.55 % in 1st and 2nd season, respectively with interaction $N_{175}*T_2$ and $N_{200}*T_2$ respectively. This reflect the effect of foliar Fe, Zn and Mn on N-uptake and consequently on the studied indices of N use efficiency.

## CONCLUSION

The present study showed that application of 175 kg N $fed.^{-1}$ with foliar application of mixed sulfate Fe, Zn and Mn at a ratio 2:1:1 at 1.25 g $L^{-1}$ could be recommended to obtain high fresh tuber yield of potato with high quality and high N efficiency.

## REFERENCES

Abdel-Kader, A. E. (2002). Effect of some organic and mineral fertilizers on some potato cultivars. M. Sc. Thesis, Fac. of Agric. Mans. Univ., Egypt.

Adamski, J. M.; J. A. Peters; R. Danieloski and M. A. Bacarin (2011). Excess iron-induced changes in the photosynthetic characteristics of sweet potato. Journal of Plant Physiology, 168: 2056- 2062.

Alloway, B.J. (2004). Zinc in Soils and Crop Nutrition. 1st Ed., International Zinc Association (IZA), Brussels, Belgium, pp: 128.

Bybordy, A. and M.J. Malakoty ( 2003). Effect of nitrogen and manganese levels on performance and quality of two species rapeseed in Ahar city (Eastern Azarbyjan). J. Sci. Res. Soil and Water, Natl. Soil Water Res. Inst. Tehran, Iran, 17: 1-8.e to nitrogen fertilization. Communications in Soil Science and Plant Analysis. 32: 1405-1429.

Butron, W. G.,(1948). “The Potato”. Chapman and Hall, London, pp:319.

Fageria, N. K. and V. C. Baligar (2001). Low land rice response to Nitrogen Fertilization Communcation in Soil Sci. and Plant Analysis,32:1405-1429.

Gomez, K. A. and A. A. Gomez (1984). "Statistical Procedures for Agricultural Research". 2nd Ed. John Wiley and Sons, pp. 680.

Goos, R.J.; Johnson, B. Jackson and G. G. Hargrove (2004). Greenhouse evaluation of controlled release iron fertilizers for soybean. J. Plant Nutr. 27: 43– 55.

Hänsch R.; and R. R. Mendel. (2009). Physiological functions of mineral micronutrients (Cu, Zn, Mn, Fe, Ni, Mo, B and Cl). Curr. Opin. Plant Biol., 12: 259–66.

Heckman, J.R. (2000). Manganese needs of soils and crops in New Jersey. New Jersey Agricultural Experiment Station.

Huggins D. R. and W. L. Pan (1993). Nitrogen efficiency component analysis: an evaluation of cropping systems differences in productivity. Agron J. 85: 898–905.

Iqbal, J.M. (1995). Response of potato crop to zinc sulfate application. Proceeding of National Seminar Held at NARC,Islamabad.

Jackson, M. L. (1967). "Soil Chemical Analysis". Printic Hall of India, New Delhi. pp 144-197.

Khalifa, R. Kh. M.; O.A. Nofal and Nadia, M. Badran (2003). Influence of foliar feeding with micronutrients on the yield and nutritional status of winter potato var. Diamond. Annuals Agric. Sci., Ain Shams Univ., Cairo, 48 (2), 473 – 483.

Li, D.; W. Cong; Z. Cai; D. Shi and F. Ouyang, (2002). Response of growth and photosynthesis of marine red tide alga Heterosigma akashiwo to iron and iron stress condition. Biotechnol. Lett. 24, 743–747.

Mohamadi, E. (2000). Study effects of nutrient elements utilization methods (Zn, Mn and Mg) on increase performance quantitative and quality of two potato species. Jehad and Agriculture Ministry Final Report of Res. Inst. Reformand Providing Sapliny and Seed.

Mohammad M. J.; S. Zuraiqi; W. Quasmeh and I. Papadopoulos (1999). Yield response and nitrogen utilization efficiency by drip-irrigated potato. Nutrient Cycling in Agroecosystems, 54: 243–249.

Mousavi, S. R.; M. Galavi and G. Ahmadvand (2007). Effect of zinc and manganese foliar application on yield, quality and enrichment on potato (*Solanum tuberosum L.,*). Asian Journal of Plant Sciences, 6: 1256-1260.

Nikolic, M.; and R. Kastori (2000). Effect of bicarbonate and Fe supply on Fe nutrition of grapevine. J. Plant Nutr. 23: 1619–1627.

Nofal, O. A., A. B. El-Nasharty and N. M. Badran (2010). Sustainable improvement of nutrients utilization using micronutrients foliar application on potato plant. International J. of Acad. Res., 2(4): 292-296.

Nofal, O.A.; M. F. El-Massri and A. A. El-Sayed (1998). Response of some potato cultivars grown on alluvial soil to micronutrients foliar spray. J. Agric. Sci. Mansoura Univ., 23: 4121-4123.

Nour,Y.M.(1992). Cultural Role of the Egypto-German Project ‘’Micronutrients and Other Plant Nutrition Problems in Egypt’’ in the Field of Fertilizers Use in Egypt. Proc. Egypto-German Seminar ‘’Environmental and Cultural Aspects of Fertilizers Use’’, 25-28 Nov. 1991, Cairo, Ed. M.M. El-Fouly, pp. 161-174 (1992).

Omil, B. (2007). Trace elements in soils and plants in temperate forest plantations subjected to single and multiple applications of mixed wood ash. Science of the Total Environment,Michigan,v.381,n.1-3,p.157-168.

Ranganna, S. (1977). "Manual of Analysis of Fruit and Vegetable Products". Central Food Technological Research Institute Mysore.

Ruza, A.; I. Skrabule and A. Vaivode (2013). Influence of nitrogen on potato productivity and nutrient use efficiency. Proc Latvian Acad. Sci., B 67: 247–253.

Sakr, A. A.; S. Risk and S. A. Ibrahim (1989). A fertilizer leaf spray for potato plants. J. Agric. Sci., Mansoura Univ., Egypt, 14: 1894 – 1900.

Tyler, K. B; F. E. Broadbent and J. C. Bishop (1983). Efficiency of nitrogen uptake by potatoes. AmPotato J, 60:261–269.

Vos, J. (2009). Nitrogen responses and nitrogen management in potato. Pot. Res. 52: 305–317.

Westermann, D. T. (2005). Nutritional requirements of potatoes. Am. J. Pot. Res., 82: 301–307.

## تأثير التسميد النيتروجينى والاضافة الورقية لبعض العناصر الصغرى على محصول البطاطس وكفاءة التسميد النيتروجينى.

**الحسينى المرسى السيد خفاجى**

**معهد بحوث الأراضي والمياه والبيئة – مركز البحوث الزراعية – الجيزة – مصر.**

أجريت تجربتان حقليتان بقرية بطرة, مركز طلخا بمحافظة الدقهلية, مصر. خلال الموسمين الشتويين لعام 2013/2012 و2014/2013 فى تصميم القطع المنشقة مرة واحدة فى 3 مكررات حيث شغلت مستويات النيتروجين القطع الرئيسية ( صفر ،150 ،175، 200 و225 كجم ن/للفدان) و الإضافة الورقية لخليط سلفات كلا من الحديد والزنك والمنجنيز كنسبة 1:1:2 فى القطع المنشقة ( صفر و 1.25 و 2.5 جم /لتر) لدراسة تأثيرها على محصول البطاطس وجودتة (صنف سيلانى) والممتص من النتروجين والفوسفور والبوتاسيوم وكفاءة التسميد النتروجينى.

**وكانت النتائج كما يلى:-**

- زاد معنويا كلا من محصول الدرنات الكلى ومتوسط وزن الدرنة ومحصول العرش الجاف مع إضافة مستويات النتروجين، وكذلك الإضافة الورقية لمخلوط كل من الحديد والزنك والمنجنيز وكان تأثير التفاعل بينها وبين مستويات النيتروجين غير معنويا.
- سجل أعلى محصول درنات طازج (18.771 و 19.648 ميجا جرام/فدان) عند تفاعل مستوى النيتروجين 200كجم/فدان مع الإضافة الورقية لمخلوط الحديد والزنك والمنجنيز عند معدل 2.5جرام/لتر.
- تأثرت النسبة المئوية للمادة الجافة فى الدرنة ونسبة البروتين ونسبة النشا معنويا بإضافة مستويات النتروجين ومعاملات الرش بينما كان تأثير التفاعل بينهما غير معنوى فى الموسمين.
- زاد الممتص من كلا من النتروجين والفوسفور والبوتاسيوم بواسطة العرش والدرنات مع إضافة مستويات النتروجين والرش بالحديد والزنك والمنجنيز زيادة معنوية بينما كان تأثير التفاعل غير معنوى.
- انخفضت قيم كفاءة استخدام النيتروجين وكفاءة الامتصاص مع الإضافة المتتالية لمستويات التسميد النيتروجيني، فى حين كانت أعلى معدل استفادة للنتروجين 36.96% عند مستوى التسميد النيتروجينى 200 كجم/فدان.
- أثر التفاعل بين معاملات الرش بالحديد والزنك والمنجنيز ومستويات اليتروجين على كفاءة استخدام النيتروجين وكفاءة الامتصاص ومعدل استفادة للنتروجين، حيث كانت معدل استفادة للنتروجين فى الموسم الأول 37.13% وفى الموسم الثاني 40.55 % عند التفاعل بين مستوى النتروجين 175, 200كجم على التوالى مع الإضافة الورقية لمخلوط الحديد والزنك والمنجنيز عند معدل 1.25جرام/لتر.