



EXCESSIVE NITROGEN FERTILIZATION OF POTATO UNDER DRIP IRRIGATION AND IMPLICATIONS ON NO₃ AND NO₂ ACCUMULATION IN PLANT AND SOIL

By

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5-Summary and Conclusion

A field experiment under drip irrigation, on potato crop (*Solanum tuberosum* L.) cv. 'Diamond', was performed at El-Qanater Horticultural Research station, Middle Nile Delta, Kalyobiya Governorate, Egypt during 2015/2016 and 2016/2017 seasons to study the effect of 3 irrigation regimes G_1 , G_2 and G_3 ; i.e. 120, 100 and 80% of ET_c , respectively. Applied irrigation water was 5119, 4265, and 3412 $m^3 ha^{-1}$ for G_1 , G_2 and G_3 , respectively. Fertilization was in 2 rates 380 and 570 $kg N ha^{-1}$ applied as urea (U), ammonium nitrate (AN) and ammonium sulphate (AS).

Main results are as follows:

First: Tuber yield

1. Non-fertilized treatments gave yields very much lower than that given by the fertilized ones. The lowest tuber yield of 10.2 $Mg ha^{-1}$ was obtained by the unfertilized low irrigation regime, increased by 71.6 and 142.8 % under medium and high irrigation regimes, respectively.
2. All fertilized treatment gave higher yield than the lowest irrigation regime of nonfertilized treatment ranged from (51.64 $Mg ha^{-1}$) 408.8% by $G_3N_1S_1$ (the low irrigation low U-N) up to (73.16 $Mg ha^{-1}$) 620.8% obtained by the treatment of $G_1N_2S_2$ (the high irrigation high AN-N treatment)
3. The lowest fertilized gave yield of 51.6 $Mg ha^{-1}$ by the low irrigation low U while the highest of 73.2 $Mg ha^{-1}$ was by the high irrigation high AN indicating a preference on AN over U or AS.
4. Increased N rate was associated with increased tuber yield.

Second: Water Relations:

1. The actual evapotranspiration (ET_0) values for the fertilized treatments averaged of 4132, 3457 and 2762 $m^3 ha^{-1}$ for the G_1 , G_2 and G_3 , respectively and the actual evapotranspiration (ET_0) pattern for fertilizers was $U > AN > AS$.

2. The highest ET_0 value of 4194 $m^3 ha^{-1}$ was recorded by high irrigation high U rate while the lowest of 2715 $m^3 ha^{-1}$ was obtained by the low irrigation low AN rate.

3. The ET_0 under application of U was greatest followed by AN and lowest under application of AS; 3489, 3450 and 3412 $m^3 ha^{-1}$ under each, respectively.

4. Under N-rates, ET_0 averaged 3438 and 3462 $m^3 ha^{-1}$ under the low rate and the high one, respectively. Application of N increased the ET_0 by averages of 6.3 and 7.1% for the low and high rates, respectively as compared with the non-fertilized treatments.

5. Irrigation water productivity (IWP) was lower for the nonfertilized treatment (2.98 $kg m^{-3}$) than the fertilized ones which gave from 11.53 by high irrigation low U rate to 18.55 $kg m^{-3}$ by low irrigation high AN rate. The pattern for irrigation regimes was $G_3 > G_2 > G_1$ with average increases of 14.2 and 36.2% for G_2 and G_3 , respectively over G_1 .

6. Application of N increased IWP by averages of 265.2 and 284.8% for N_1 and N_2 , respectively as compared with the non-fertilized treatments.

7. The pattern for N sources was $AN > AS > U$

Third: Contents of NO_3-N and NO_2-N in fresh potato tubers ($mg kg^{-1}$):

1. Lower contents ($mg kg^{-1}$) of NO_3-N in fresh tubers were in the non-fertilized (118, 159 and 139 $mg kg^{-1}$ under high, medium and low

irrigation regimes, respectively). Under fertilization, contents of 441 (low irrigation low AS rate) to 578 mg kg⁻¹ (high irrigation high AN rate) indicating high nitrate content in fresh tuber with fertilization at high AN rate.

2. Average NO₃-N contents at high N rate was 520 mg kg⁻¹ compared with 478 mg kg⁻¹ at low N. Averages for high, medium and low irrigation regimes were 525, 497 and 476 mg kg⁻¹, respectively. Averages for U, AN and AS were 483, 515 and 498 mg kg⁻¹, respectively.

3. Contents of NO₂-N in fresh tubers (mg kg⁻¹) were lower in the non-fertilized treatments, being 0.050, 0.131, and 0.115 mg kg⁻¹ for the low, medium and high irrigation regimes, respectively. For the fertilized treatments contents ranged from 0.060 mg kg⁻¹ (low irrigation low U rate) to 0.181 mg kg⁻¹ (high irrigation low AN rate) .

4. Average NO₂-N at high N rate was 0.111 mg kg⁻¹ compared with 0.101 mg kg⁻¹ at low N rate. Averages for low, medium and high irrigation regimes were 0.80, 0.100 and 0.138 mg kg⁻¹, respectively. Averages for U, AN and AS were 0.104, 0.118 and 0.096 mg kg⁻¹, respectively.

Fourth: Contents of N, P and K in dry potato tubers (g kg⁻¹):

Nitrogen, Nonfertilized contained less N in DW of tubers than the fertilized ones. Their averages were 4.2, 3.4 and 2.8 g kg⁻¹ under high, medium and low irrigation regimes, respectively. Fertilized treatments contained from 6.6 (high irrigation low U rate) to 12.6 g kg⁻¹ (low irrigation high AS rate). Averages for irrigations were 8.4, 10.6 and 11.0 g kg⁻¹ for high, medium and low irrigation regimes, respectively. Those for N sources were 9.4, 10.2 and 10.4 g kg⁻¹ for U, AN and AS, respectively. Averages for N rates were 9.3 and 10.7 g kg⁻¹ for low and high N, respectively.

Phosphorus, Nonfertilized contained less P in DW of tubers than the fertilized ones. Their averages were 2.1, 1.9 and 2.6 g kg⁻¹ under high, medium and low irrigation regimes, respectively. Fertilized treatments contained ranged from 2.2 (medium irrigation low U rate) to 2.8 g kg⁻¹ (high irrigation high U rate). Averages for irrigations were 2.6, 2.4 and 2.6 g kg⁻¹ for high, medium and low irrigations, respectively. Those for N sources were 2.5, 2.6 and 2.5 g kg⁻¹ for U, AN and AS, respectively. Averages for N rates were 2.5 and 2.6 g kg⁻¹ for low and high N rates, respectively.

Potassium, Nonfertilized treatments contained less K in DW of tubers than the fertilized (exception of G₁N₀). Their averages were 28.0, 24.5 and 16.9 g kg⁻¹ under high, medium and low irrigation regimes, respectively. Fertilized treatments contained from 22.9 (high irrigation low AN rate) to 32.8 g kg⁻¹ (high irrigation low U rate). Averages for irrigation were 29.7, 26.0 and 26.2 g kg⁻¹ for high, medium and low irrigation regimes, respectively. Those for N sources were 27.2, 28.0 and 26.7 g kg⁻¹ for U, AN and AS, respectively. Averages for N rates were 26.5 and 27.9 g kg⁻¹ for low and high N rate, respectively.

Fifth: Contents of dry matter in fresh potato tubers (g kg⁻¹):

Nonfertilized treatments contained higher dry matter in fresh tubers than the fertilized (with exception). Their averages were 209 , 211 and 231 g kg⁻¹ under high, medium and low irrigation regimes, respectively. Fertilized treatments contained ranged from 182 (high irrigation low AN rate) to 238 g kg⁻¹ (low irrigation high U rate). Averages for irrigations were 188, 206 and 212 g kg⁻¹ for high, medium and low irrigation regimes, respectively. Those for N sources were 204, 199 and 204 g kg⁻¹ for U, AN and AS, respectively. Averages for N rates were 196 and 208 g kg⁻¹ for low and high N, respectively.

Sixth: Contents of protein in dry potato tubers (g kg⁻¹):

Nonfertilized treatments contained less protein than the fertilized. Their averages were 26.5, 21.2 and 17.2 g kg⁻¹ under high, medium and low irrigation regimes, respectively. The fertilized treatments contained from 41.4 (high irrigation low U rate) to 78.4 g kg⁻¹ (low irrigation high AS rate). Averages for irrigations were 52.8, 66.1 and 68.9 g kg⁻¹ for high, medium and low irrigation regimes, respectively. Those for N sources were 58.8, 63.8 and 65.2 g kg⁻¹ for U, AN and AS, respectively. Averages for N rates were 58.4 and 66.8 g kg⁻¹ for low and high N, respectively

Seventh: Contents of starch in dry potato tubers (g kg⁻¹):

Nonfertilized treatments contained higher starch in DW of tubers than the fertilized (with exception). Their averages were 147, 149 and 166 g kg⁻¹ under high, medium and low irrigation regimes, respectively. Fertilized treatments contained ranged from 123 (high irrigation low AN rate) to 173 g kg⁻¹ (low irrigation high U rate). Averages for irrigations were 129, 144 and 150 g kg⁻¹ for high, medium and low irrigation regimes, respectively. Those for N sources were 142, 138 and 143 g kg⁻¹ for U, AN and AS, respectively. Averages for N rates were 135 and 146 g kg⁻¹ for low and high N, respectively.

Eighth: Contents of Carbohydrate in dry potato tubers (g kg⁻¹):

Nonfertilized treatments contained less carbohydrates than the fertilized (with exception). Their averages were 510, 698 and 630 g kg⁻¹ for the high, medium and low irrigation regimes, respectively. Fertilized treatments contained from 506 (high irrigation high AS rate) to 834 g kg⁻¹ (medium irrigation low AS rate). Averages for irrigations were 658, 666 and 639 g kg⁻¹ for high, medium and low irrigation regimes, respectively. Those for N sources were 651, 639 and 673 g kg⁻¹ for U,

AN and AS, respectively. Averages for N rates were 721 and 588 g kg⁻¹ for low and high N, respectively.

Ninth : N, P and K uptake by potato tuber (kg ha⁻¹):

Nitrogen uptake: Nonfertilized treatments gave N uptake lower than the fertilized ones and their averages were 21.9, 12.5 and 6.5 kg ha⁻¹ under high, medium and low irrigation regimes, respectively. Fertilized treatments gave 50.5 (high irrigation low U rate) to 169.1 kg ha⁻¹ (low irrigation high AS rate). Averages for irrigations were 82.0, 122.8 and 132.7 kg ha⁻¹ for high, medium and low irrigation regimes, respectively. Those for N sources were 97.0, 120.3 and 120.3 kg ha⁻¹ for U, AN and AS, respectively. Averages for N rates were 97.2 and 127.7 kg ha⁻¹ for low and high N, respectively.

Phosphorus uptake: The nonfertilized treatments gave P uptake lower than the fertilized ones and their averages were 10.8, 7.2 and 6.1 kg ha⁻¹ under high, medium and low irrigation regimes, respectively. Fertilized treatments gave their lowest P-uptake 16.5 kg ha⁻¹ under the medium irrigation low U rate and their highest of 32. Kg ha⁻¹ under the low irrigation high AS rate. Averages for irrigations were 20.9, 23.5 and 26.0 kg ha⁻¹ for the high, medium and low irrigation regimes, respectively. Averages for N sources were 21.4, 25.3 and 23.7 kg ha⁻¹ for U, AN and AS, respectively. Averages for N rates were 21.0 and 26.0 kg ha⁻¹ for low and high N, respectively

Potassium uptake: Nonfertilized treatments gave K uptake by potato tubers lower than that of the fertilized ones. Their averages were 144.4, 90.2 and 39.5 kg ha⁻¹ in high, medium and low irrigation regimes, respectively. Fertilized treatments gave from 167.0 (high irrigation regime low AS rate) to 327 kg ha⁻¹ (medium irrigation high AN rate). Averages for irrigations were 218, 260 and 290 kg ha⁻¹ for high, medium,

and low irrigation regimes, respectively. Those for N sources were 225, 275 and 267 kg ha⁻¹ for U, AN and AS, respectively. Averages for N rates were 235 and 276 kg ha⁻¹ for low and high N, respectively.

Tenth: Contents of chlorophyll (a+b) in fresh potato foliage (mg g⁻¹):

Generally, nonfertilized contained less chlorophyll than the fertilized. The nonfertilized contained averages of 2.48, 2.04 and 1.76 mg g⁻¹ for the high, medium and low irrigation regimes, respectively. The fertilized contained from 2.46 to 4.18 mg g⁻¹ for low irrigation low U rate, and high irrigation high AN rate, respectively. Averages for irrigation were 3.93, 3.42 and 2.92 mg g⁻¹ under high, medium and low irrigation regimes, respectively. Averages for the N sources were 3.40, 3.57 and 3.31 mg g⁻¹ for U, AN and AS, respectively; and averages for the N rates were 3.29 and 3.55 mg g⁻¹ for the low and high, respectively.

Eleventh: Contents of NO₃-N and NO₂-N in soil after harvested (mg kg⁻¹):

1. Lower contents of NO₃-N were in the non-fertilized treatments (79, 119 and 187 mg kg⁻¹ under high, medium and low irrigation regimes, respectively). Under fertilization, contents ranged from 198 (high irrigation low AS rate) to as high as 442 mg kg⁻¹ (high irrigation high AS rate)

2. Average NO₃-N at high N rate was 359 mg kg⁻¹ compared with 268 mg kg⁻¹ at low N. Averages for high, medium and low irrigation regimes were 327, 301 and 313 mg kg⁻¹, respectively. Averages for U, AN and AS were 309, 321 and 311 mg kg⁻¹, respectively.

3. Contents of NO₂-N in soil (mg kg⁻¹) were higher in the non-fertilized treatments, being 0.172, 0.100 and 0.043 mg kg⁻¹ for the high, medium and low irrigation regimes, respectively). For the fertilized contents

ranged from 0.010 (medium irrigation low U rate) to 0.22 mg kg⁻¹ (low irrigation high U rate).

4. Average NO₂-N content at high N was 0.085 mg kg⁻¹ compared with 0.058 mg kg⁻¹ at low N. Averages for low, medium and high irrigation regimes were 0.038, 0.074 and 0.102 mg kg⁻¹, respectively. Averages for U, AN and AS were 0.074, 0.051 and 0.089 mg kg⁻¹, respectively.