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# EFFECT OF DIFFERENT LEVELS OF NITROGEN ON VEGETATIVE GROWTH, MINERAL CONTENT AND NUTRIENT UPTAKE OF "WILLIAMS" BANANA PLANTS GROWN IN SAND CULTURE.

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## ABSTRACT

This work was carried out for two seasons on young banana plants (*Musa cavendishii* cv. "Williams Hybrid") grown in sand culture. The experiment included five levels of nitrogen in the nutrient solution, namely 0%, 50%, 100 % (Standard Nutrient Solution) (S.N.S.), 200% and 400% N. Generally in both the two seasons, removing nitrogen from the nutrient solution gave the lowest values of all vegetative growth parameters than those of other treatments and the old leaves at the base of plant acquired a yellowish colour which covered most leaf blade leaving a narrow area with faint green colour along the midrib. On the other hand, all vegetative growth parameters were gradually increased by increasing nitrogen level in the nutrient solution. The maximum increase was obtained by (100% N) treatment. More increase in nitrogen level (200 % and 400%N) treatments reduced vegetative growth of the plants.

Regarding nitrogen distribution in different parts of the plant supplied with (S.N.S.), leaf blade had the highest amount of nitrogen uptake which attained (73.86%) followed in decreasing order by those in pseudostem (17.43%), leaf petioles (3.26%), corm (3.16%) and roots (2.29%), respectively. Thus, it is clear that leaf blade had more amount of nitrogen than those of other plant parts. This affirms that, leaves are a proper organ to diagnose nitrogen status of "Williams" banana plants.

Blade samples from leaves of similar age (the blade of the third leaf from the top of the plant) were taken at three different times for mineral analysis. Although samples were taken from leaves of similar age, nitrogen, phosphorus and potassium contents were higher in

August sample than those sampled in December or April. Thus, time of sampling had a pronounced effect on leaf mineral content.

Regarding the effect of nitrogen treatments on mineral content, it appeared that nitrogen treatments affected nitrogen content considerably. Removing nitrogen from the nutrient solution reduced nitrogen content to about 1.04-1.64%, this range means lack (deficiency) of nitrogen. However, nitrogen content was increased and ranged between 2.46-2.67% in leaf blades when plants were supplied with 50%N in nutrient solution. This means that nitrogen is low. Nitrogen content in leaf blade in plants supplied with (S. N. S.) ranged between 2.76-2.86%. This means that nitrogen is optimum. Increasing nitrogen supply up to 200%N, increased nitrogen content and the percentage of nitrogen ranged between 2.85-3.09%. This means that nitrogen is high. More increase in nitrogen supply (400%N) increased nitrogen content and ranged between 3.07-4.10% .This could be considered that nitrogen is very high (excess).

With respect to other elements, removing nitrogen decreased N and P but increased K content in leaves. However, there was a gradual increase in phosphorus content by increasing nitrogen level in the nutrient solution. On the other hand, the increase of nitrogen in nutrient solution decreased potassium content significantly and the highest nitrogen level (400%) gave the least potassium value.

**Key words:** Nitrogen, sand culture, banana plants (*Musa cavendishii* cv.: "Williams Hybrid"), content and uptake of minerals.

## INTRODUCTION

This research was carried out to study the effect of different levels of nitrogen on growth, mineral content and nutrients uptake of young banana plants (*Musa cavendishii* cv.: "Williams Hybrid") grown in sand culture. No doubt, this study may be helpful to determine the low, optimum and high levels of nitrogen which in turn will be important in arriving at a proper program for banana fertilization.

## MATERIALS AND METHODS

The present study was conducted for two successive seasons (2005/2006 and 2007/2008) to study the effect of different levels of nitrogen on growth, mineral content and nutrients uptake of young banana plants (*Musa cavendishii* cv. "Williams Hybrid") grown in sand culture. Plants were growing in a plastic house, Faculty of Agriculture, Ain Shams Univ., Shoubra EL- Kheima, Egypt.

To start the experiment with similar plants of banana, plantlets were produced by *in vitro* culture technique and repotted under controlled conditions in plastic house up to the last week of July when plants had 5-7 leaves, then plants were selected for uniformity and one plant was transplanted to a new plastic container. The dimensions of each container were 60 cm, 40 cm and 35 cm for the upper, lower diameters and the height, respectively. These plastic containers (60-litre- capacity) were filled with sand which was previously treated with 10% commercial hydrochloric acid for 24 hours, then thoroughly washed with tap water then washed again several times with deionized water to free it from all solutes and any trace of acid. All plants were fertilized with the Standard Nutrient Solution (S.N.S.) of Long Ashton (Table 1) for macronutrients and (Table 2) for micronutrients according to Hewitt (1966) but with different concentrations of nitrogen. Nitrogen treatments relative to N in the S.N.S. were 0%, 50%, 100 % (S.N.S.), 200% and 400% N. The analogous concentrations of N in ppm were 0, 56.5, 113.0, 226.0 and 452.0, respectively. Thus, the experiment included five treatments. Plants were supplied every other day with the different diluted solutions at a rate of 2 liter / plant. Each treatment was replicated five times on one-plant-plots in a completely randomized design. It should be pointed out that leaching requirement had been carried out every 2 weeks by a rate of 2 liter / container with deionized water.

**Table (1): Macronutrients composition of Long Ashton standard complete nutrient solution based on ammonium sulphate at 8 mg. equiv. /l.**

| Salt | mg. equiv./l | | | | ppm | | | | mM. | Wt.(g) | Stock solution used to prepare 100 l of nutrient solution |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $MgSO_4.7H_2O$ | $Mg^{++}$ | 3.0 | $SO_4^{--}$ | 3.0 | Mg | 36 | S | 48 | 1.5 | 36.8 | 200 ml |
| $Na_2HPO_4.12H_2O$ | $Na^{+}$ | 2.67 | $PO_4^{---}$ | 4.0 | Na | 62 | P | 41 | 1.33 | 47.8 | 400 ml |
| $K_2SO_4$ | $K^{+}$ | 4.0 | $SO_4^{--}$ | 4.0 | K | 156 | S | 64 | 2.0 | 34.8 | 400 ml |
| $CaCl_2$ | $Ca^{++}$ | 8.0 | $Cl^{-}$ | 8.0 | Ca | 160 | Cl | 284 | 4.0 | 44.4 | 200 ml |
| $(NH_4)_2SO_4$ | $NH_4^{+}$ | 8.0 | $SO_4^{--}$ | 8.0 | N | 113 | S | 128 | 4.0 | 52.8 | 200 ml |

**Table (2): Micronutrients composition of Long Ashton standard complete nutrient solution.**

| Salt | mg. equiv./l | mM. Conc. | ppm | stock solution used to prepare 1000 l of nutrient solution |
|---|---|---|---|---|
| Fe Na EDTA | 0.15 | 0.05 | 2.8 Fe | 18.6 g / l |
| $MnSO_4.4H_2O$ | 0.02 | 0.01 | 0.55 Mn | 2.20 g / l |
| $CuSO_4.5H_2O$ | 0.002 | 0.001 | 0.064 Cu | 0.256 g / l |
| $ZnSO_4.7H_2O$ | 0.002 | 0.001 | 0.065 Zu | 0.287 g / l |
| $H_3BO_3$ | 0.15($B^3$) | 0.05 | 0.54 B | 3.05 g / l |
| $Na_2MoO_4.2H_2O$ | 0.003($Mo^6$) | 0.0005 | 0.048Mo , 0.07 Na | 0.120 g / l |

**Vegetative characteristics: -**

The following measurements were determined monthly from the last week of August up to the last week of the next August in each season:-

a- Plant height was measured from the ground surface up to the top of the pseudostem in cm.

b- Pseudostem circumference was measured at 5 cm above ground surface in cm.

c- Total number of leaves per plant was counted.

d- Blade area ($cm^2$) was calculated by measuring the length and width of the blade of the third full expanded leaf from the top of the plant. The area was calculated by multiplying the product of length and width of the balde by the factor 0.8 (Murray, 1960).

e- Total chlorophyll content was measured in the third full expanded leaf from plant top in early December, April and August in each season by using a SPAD – 502 MINOLTA chlorophyll meter. The SPAD – 502 meter determines the relative amount of chlorophyll present by measuring the transmittance of the leaf in two wave length regions (the red and near-infrared). Using these two transmittance, the meter calculates a numerical SPAD value which is proportional to the amount of chlorophyll present in the leaf.

At the end of each season in August (after thirteen months from planting) all plants were taken out carefully and separated into five parts (roots, corm, pseudostem, petioles and leaf blades). The fresh weight of roots, corm and pseudostem were determined. Thereafter, amples of about 100g were taken from each of roots, corm (by cutting a longitudinal section from the middle part of the corm) and pseudostem (by cutting a cross section from the middle part of the pseudostem).

Regarding the leaves and petioles it should be pointed out that the third leaf from the top of the plant was taken from each plant and separated in two parts (blade and petiole) and the fresh weight of each part was taken. Then the total fresh weight of leaves and petioles were calculated by multiply the number of leaves or petioles by weight of each part. The different fresh samples were washed with tap water and rinsed with distilled water then oven dried at 60-70°C until a constant weight then the dry weight of each part was determined. Thereafter, the fresh and dry weights of total plant were calculated.

**Chemical analysis:-**

In early December, April and August in both seasons, a sample from the middle part of the third leaf from the top of each plant was taken by cutting about 10 cm wide strips from both sides of the midrib as recommended by Hewitt, 1955 for nutrient analyses. The samples were washed with tap water and rinsed with distilled water then oven dried at 60-70°C and ground for mineral analysis as will be mentioned later.

At the end of each season, samples from different plant organs (roots, corm, pseudostem, petioles and middle part of the blade without midrib were taken for nutrient determinations to calculate nutrients uptake in each organ and total plant.

**Methods of nutrients determination:-**

Dried samples were ground by means of stainless steel rotary knife mill then digested according to the method of Jackson, 1967 and the digested solutions were used to determine each of nitrogen, phosphorus and potassium .Total nitrogen was determined by micro Kjeldahl method as described by Pregl, 1945. Phosphorus was determined by means of a spectrocolourimeter, using the method of Truog and Meyer, 1929. Potassium content was estimated by a flame photometer according to Brown and Lilleland, 1946. The content of each nutrient was expressed as a percent of dry matter.

**Statistical analysis**

As mentioned before, the experiment included five treatments and each treatment was replicated five times on one-plant-plots in a completely randomized design. The part concerned with the effect of different levels of nitrogen fertilization and sampling dates on banana plants was statistically analyzed as a factorial experiment in a completely randomized design. All data obtained were statistically analyzed by using the analysis of variance (Snedecor and Cochran, 1980). Means were differentiated by Duncan's multiple range test at 5 % level (Duncan, 1955).

## RESULTS AND DISCUSSION

**Effect of different levels of nitrogen on vegetative growth.**

**A- Effect on circumference and height of pseudostem:**

In the two seasons data in (Tables 3 and 4) indicated that, height and circumference of pseudostem were increased gradually by time

and the highest values were obtained in August (thirteen months after planting). Regarding nitrogen treatments, removing nitrogen showed significant decrease in circumference and height of the pseudostem when compared with any other treatment on any given date. However, the circumference and height of the pseudostem was increased gradually by increasing N concentration in the nutrient solution .The maximum values were obtained by the Standard Nutrient Solution (S.N.S) (100% N treatment). Increasing N in the nutrient solution (200%N treatment) reduced the circumference and height of pseudostem. More increase in nitrogen (400%N treatment) led to induce more decrease in the circumference and height of the pseudostem.

Thus, it seems that (S.N.S) treatment gave the highest value of circumference and height of the pseudostem of "Williams" banana plants in the two seasons.

**B- Effect on total number of leaves:**

Generally, results in (Table 5) revealed that in the two seasons, number of leaves was increased gradually by time and the highest values were obtained in August (thirteen months after planting). With respect to nitrogen treatments, removing nitrogen showed the least significant values of total number of leaves per plant. This was true in any given month during the two seasons. On the other hand, treating with 100%N (S.N.S. treatment) gave the highest values of total number of leaves per plant in any given month except in August 2007. Reducing nitrogen (50%N) or increasing nitrogen (200%N) reduced number of leaves per plant. Excess of nitrogen (400%N) induced more decrease in number of leaves per plant.

**C-Effect on blade area:**

Results in (Table 6) show that, the area of leaf blade was increased gradually by time and the highest values were obtained in August (thirteen months after planting). Regarding nitrogen treatments, removing nitrogen (0%N treatment) gave the least significant values in any given month in the two seasons. However, other treatments behaved in a particular manner in each season. In the first season, treatments (50%N), (100%N) and (200%N) gave more or less similar values in most cases. However, treatment (100%N) tended to give higher values than those of 200 or 400 %N treatments.

In the second season, from August to December, treatment (200%N) gave the highest values for blade area followed in decreasing order by that of (100%N). Whereas, in the later period of the season (from January to August) treatment (100%N) gave the highest significant values. On the other hand, in both the two seasons, the highest nitrogen level (400%N) gave lower values than those of the preceding two treatments.

**Table (3): Effect of different levels of nitrogen on pseudostem circumference of "Williams" banana plants grown in sand culture during two seasons.**

| Treatments N%* in N.S. | Pseudostem circumference in (cm) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May. | Jun. | Jul. | Aug. |
| | | | | | | 2005/2006 season | | | | | | | |
| 0 | 5.5d | 6.6b | 7. 3c | 7.2c | 7. 4c | 7.9c | 8.2c | 8.7c | 9.6c | 10.1c | 10.6c | 12.4c | 14. 0c |
| 50 | 7.8c | 11.1a | 11.3b | 16.6a | 17.7a | 18.2a | 18.9a | 20.7a | 21.9a | 23.3a | 24.9a | 28.5a | 30.4a |
| 100(S.N.S.) | 8.8ab | 10.9a | 14.1a | 17.0a | 17.8a | 18.1a | 18.3a | 19. 5al | 23.1a | 25.4a | 27.1a | 29.2a | 30.6a |
| 200 | 9.2a | 12.3a | 14.3a | 16.6a | 16.9ab | 17.4ab | 17.8a | 19.2ab | 21.9a | 23.7a | 25.9a | 28.3a | 29.8a |
| 400 | 8.1bc | 11.0a | 13.4a | 14.4b | 14.9b | 15.0b | 15.1b | 17.4b | 18.3b | 19.5b | 21.0b | 22.9b | 23.4b |
| | | | | | | 2007/2008 season | | | | | | | |
| 0 | 6.0b | 6. 7b | 7.0b | 7.5c | 8. 0c | 8.3d | 8.5c | 8.8d | 8.8d | 11.3d | 11. 7c | 12. 3c | 12. 7b |
| 50 | 7.3a | 9. 3a | 11.7a | 13.0ab | 15. 0ab | 15.8b | 16. 7a | 17.8b | 19.2b | 22.3ab | 24. 7a | 26. 0a | 26. 0a |
| 100(S.N.S.) | 7. 7a | 9. 7a | 10. 7a | 13.3a | 15. 7a | 17.8a | 18.4a | 19.8a | 21. 3a | 23.5a | 24. 0a | 25. 7ab | 27. 0a |
| 200 | 8. 0a | 10. 3a | 11.8a | 13.3a | 14.5ab | 16.3b | 17.2a | 17.8b | 19. 0b | 21.0bc | 23. 0ab | 23. 7ab | 25. 3a |
| 400 | 7. 7a | 9. 7a | 11.3a | 12.0b | 13.2b | 13.7c | 14. 3b | 15.0c | 16. 0c | 19.0c | 21. 3b | 23. 3b | 24. 3a |

* N% relative to nitrogen in the Standard Nutrient Solution (S.N.S.). N.S. = Nutrient Solution.

Values having the same letters in the same column in each season are not statistically different by Duncan 's multiple range test, 5% level.

**Table (4): Effect of different levels of nitrogen on pseudostem height of "Williams" banana plants grown in sand culture during two seasons.**

| Treatments N% in N.S. | Pseudostem height in (cm) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May. | Jun. | Jul. | Aug. |
| | | | | | | 2005/2006 season | | | | | | | |
| 0 | 25.6 d | 33.0 b | 34.6 c | 35.8 c | 37.4d | 39.0 d | 40.4 c | 41.0 c | 42.8 c | 44.8 c | 47.6 d | 51.0c | 53.4 d |
| 50 | 33.6 c | 49.6 a | 55.0ab | 61.8 a | 64.4 b | 66.8 al | 70.4 a | 76.2 a | 94.8 a | 98.8 a | 104.4ab | 107.6a | 114.6ab |
| 100(S.N.S.) | 42.4al | 48.6 a | 56.8 b | 64.4 a | 71.2 a | 72.0 a | 73.0 a | 77.2 a | 101.0 a | 105.0 a | 112.2a | 113.2a | 120.0a |
| 200 | 45.4 a | 49.8 a | 54.8ab | 58.8ab | 62.0bc | 63.6bc | 65.8ab | 75.4 a | 88.6ab | 91.8ab | 96.2bc | 100.4ab | 104.2 b |
| 400 | 38.4 b | 46.4 a | 48.8 b | 52.6 b | 55.8c | 58.0 c | 59.6 b | 69.6 b | 76.6 b | 80.0 b | 84.0 c | 89.20 b | 90.6 c |
| | | | | | | 2007/2008 season | | | | | | | |
| 0 | 24. 0a | 26. 3d | 26. 3d | 28. 0c | 28. 0c | 28. 7c | 30. 0c | 33. 0c | 34. 0d | 47. 7d | 49.0d | 50.3d | 54.7d |
| 50 | 27. 7a | 35. 3bc | 40. 7bc | 45. 7ab | 52. 0ab | 56.0a | 58. 3b | 65.0b | 75. 0b | 89. 0b | 93.7b | 98.3b | 104.7b |
| 100(S.N.S.) | 27. 7a | 37. 3ab | 43. 0ab | 50. 0a | 56. 7a | 61. 3a | 67. 3a | 76. 7a | 87.0a | 100.0a | 106.7a | 114.7a | 116.3a |
| 200 | 26. 7a | 40. 0a | 45. 3a | 50. 0a | 55. 0a | 59. 0a | 67. 0a | 73. 7a | 80. 3b | 91. 7b | 93.7b | 98.0b | 100.0bc |
| 400 | 28. 0a | 33. 3c | 38. 0c | 41. 7b | 45. 7b | 50. 3b | 57. 3b | 62. 0b | 66. 3c | 81. 7c | 85.0c | 87.0c | 94.7c |

* N% relative to nitrogen in the Standard Nutrient Solution (S.N.S.). N.S. = Nutrient Solution.
Values having the same letters in the same column in each season are not statistically different by Duncan 's multiple range test, 5% level.

**Table (5): Effect of different levels of nitrogen on total number of leaves of "Williams" banana plants grown in sand culture during two seasons.**

| Treatments N% * in N.S. | No. of leaves per plant | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May. | Jun. | Jul. | Aug. |
| **2005/2006 season** | | | | | | | | | | | | | |
| 0 | 9.2 b | 11.0b | 12.0c | 12.2b | 13.0b | 13.0c | 13.6c | 14.8c | 16.6c | 17.8c | 18.4c | 18.8c | 19.8c |
| 50 | 10.2al | 12.6ab | 14.0ab | 15.0a | 16.0a | 16.4ab | 17.2b | 19.0b | 21.8ab | 23.8ab | 26.4ab | 28.2ab | 30.2a |
| 100(S.N.S.) | 10.6a | 13.2a | 15.2a | 16.4a | 17.4a | 17.8a | 18.8a | 20.8a | 23.4a | 25.4a | 27.6a | 29.6a | 30.6a |
| 200 | 10.2al | 12.0ab | 13.2b | 15.2a | 16.0a | 16.2b | 17.2b | 19.0b | 21.4b | 23.6b | 26.0ab | 27.8ab | 29.6ab |
| 400 | 10.6a | 13.2a | 15.0a | 16.2a | 17.0a | 17.0ab | 17.6ab | 19.6ab | 21.8ab | 23.4b | 25.2b | 27.2b | 27.8b |
| **2007/2008 season** | | | | | | | | | | | | | |
| 0 | 7.6 b | 9.3 b | 9.6 c | 10.7c | 11.3d | 12.0d | 12. 3c | 12. 7b | 13. 0b | 16. 3c | 17.0c | 17.3c | 18.3d |
| 50 | 8.3 ab | 12.0a | 13.7a | 15.0a | 16. 0ab | 16.3ab | 17. 0ab | 18. 0a | 20. 0a | 22. 7ab | 24.3a | 26.3a | 27.0b |
| 100(S.N.S.) | 8.6 ab | 12.3a | 14.0a | 15.3a | 16. 3a | 17.0a | 17. 7a | 18. 0a | 20. 3a | 24. 0a | 25.0a | 27.7a | 29.3a |
| 200 | 9.0 a | 12.0a | 13.3ab | 14.3ab | 15. 0bc | 15. 7b | 16. 3b | 17. 0a | 19. 3a | 22. 3b | 24.3a | 26.0a | 27.7b |
| 400 | 8.3 ab | 11.7a | 12.7b | 13.7b | 14. 7c | 15. 3c | 16. 0b | 17. 0a | 19. 7a | 21. 7b | 22.7b | 24.0b | 25.0c |

* N% relative to nitrogen in the Standard Nutrient Solution (S.N.S.). N.S. = Nutrient Solution.
Values having the same letters in the same column in each season are not statistically different by Duncan 's multiple range test, 5% level.

**Table (6): Effect of different levels of nitrogen on blade area of "Williams" banana plants grown in sand culture during two seasons.**

| Treatments N%* in N.S. | Area of blade of the third leaf from the top of plant in $cm^2$ | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May. | Jun. | Jul. | Aug. |
| | | | | | | 2005/2006 season | | | | | | | |
| 0 | 259 d | 324 c | 370 c | 384 c | 480 c | 499 c | 584 c | 610 c | 629 c | 666 c | 696 d | 708 d | 720 e |
| 50 | 702 b | 1173 a | 1395 a | 1457 a | 1527 a | 1530 a | 2020 a | 2112 a | 2243 a | 2454 a | 2883 a | 2938 a | 3069 a |
| 100(S.N.S.) | 767 al | 1194 a | 1254 ab | 1367 ab | 1554 a | 1586 a | 1938 a | 2143 a | 2347 a | 2474 a | 2656 ab | 2771 a | 2870 b |
| 200 | 832 a | 1129 a | 1261 ab | 1298 ab | 1391 a | 1414 a | 1834 a | 1928 a | 2193 a | 2258 a | 2462 b | 2550 b | 2663 c |
| 400 | 590 c | 969 b | 1082 b | 1152 b | 1196 b | 1196 b | 1401 b | 1479 b | 1590 b | 1685 b | 1822 c | 1916 c | 2009 d |
| | | | | | | 2007/2008 season | | | | | | | |
| 0 | 316 c | 344 d | 365 d | 379 c | 419 c | 437 c | 492 d | 621 d | 694 d | 957 d | 961 d | 963 d | 967 d |
| 50 | 380 b | 764 c | 788 c | 883 b | 987 b | 1167 a | 1337 bc | 1543 b | 1788 b | 2179 b | 2199 b | 2221 b | 2277 b |
| 100(S.N.S.) | 426 a | 1003 b | 1036 b | 1070 ab | 1229 ab | 1411 a | 1659 a | 1853 a | 2045 a | 2440 a | 2500 a | 2581 a | 2596 a |
| 200 | 444 a | 1228 a | 1261 a | 1299 a | 1333 a | 1385 a | 1493 ab | 1496 b | 1716 b | 2030 bc | 2068 b | 2111 b | 2133 b |
| 400 | 312 c | 645 c | 837 bc | 903 b | 1011 ab | 1060 b | 1117 c | 1133 c | 1387 c | 1814 c | 1833 c | 1900 c | 1953 c |

* N% relative to nitrogen in the Standard Nutrient Solution (S.N.S.). N.S. = Nutrient Solution.
Values having the same letters in the same column in each season are not statistically different by Duncan 's multiple range test, 5% level.

**D-Effect on fresh and dry weight of different parts and total plant of "Williams" banana:**

Results in (Table 7) indicted that, in the two seasons, fresh and dry weight of different parts and total plant at the end of each season were affected significantly by different levels of nitrogen. Generally, in the two seasons, removing nitrogen from the nutrient solution gave the least significant values of fresh and dry weights.

With respect to fresh weight of different parts, treatments (100%N) and (200%N) gave similar values in the two seasons but these values were significantly higher than those of other treatments. On the other hand, decreasing or increasing nitrogen concentration in the nutrient solution (treatments 50%N and 400%N) tended to

decrease fresh weight of different parts and total plant significantly than those of the above two treatments.

**Table (7) Effect of different levels of nitrogen on fresh and dry weights of different parts and total plant of "Williams" bananas grown in sand culture during two seasons.**

| Treatments N% in N.S. | Fresh weight (g) | | | | | | Dry weight (g) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Roots | Corm | Pseudostem | Petioles | Blades | Total plant | Roots | Corm | Pseudostem | Petioles | Blades | Total plant |
| | | | | | | 2005/2006 season | | | | | | |
| 0 | 103d | 125b | 229c | 60c | 246d | 764c | 3.3c | 3.4b | 6.2b | 2.2c | 26d | 41c |
| 50 | 255c | 412ab | 2567b | 260b | 2951c | 6445b | 14.0b | 16.8a | 81.3a | 30.3b | 315bc | 457b |
| 100(S.N.S.) | 378b | 523a | 3184a | 413a | 3380ab | 7878a | 28.1a | 18.1a | 98.1a | 34.7a | 384a | 563a |
| 200 | 501a | 467a | 3119a | 326ab | 3600a | 8007a | 28.0a | 15.4a | 96.2a | 28.1b | 353ab | 521a |
| 400 | 336b | 398ab | 2768ab | 360ab | 3188bc | 7050b | 17.5b | 13.7a | 83.3a | 29.4b | 283c | 427b |
| | | | | | | 2007/2008 season | | | | | | |
| 0 | 155c | 100d | 178c | 66c | 254c | 753c | 5.2d | 3.7c | 8.0c | 1.6d | 26b | 44c |
| 50 | 251b | 355c | 2212b | 378a | 2160b | 5356b | 16.2bc | 13.4b | 53.1b | 18.7b | 176ab | 277ab |
| 100(S.N.S.) | 308ab | 500b | 2912a | 397a | 2464ab | 6581a | 21.0ab | 25.6a | 87.7a | 18.2b | 198ab | 350ab |
| 200 | 357a | 567a | 2967a | 426a | 2813a | 7129a | 23.2a | 27.7a | 88.3a | 25.4a | 256a | 420a |
| 400 | 234bc | 371c | 2292b | 216b | 1833b | 4946b | 13.6c | 14.0b | 65.2b | 7.6c | 137ab | 237b |

* N% relative to nitrogen in the Standard Nutrient Solution (S.N.S.). N.S. = Nutrient Solution.
Values having the same letters in the same column in each season are not statistically different by Duncan 's multiple range test, 5% level.

Regarding dry weight, increasing nitrogen in the nutrient solution increased dry weight of different parts and total plant but the effect of treatments varied from season to season. In the first season, (100%N) and (200%N) treatments gave the highest significant value of dry weight of roots and blades when compared with any other treatment. Whereas, dry weight of roots and blades were reduced by increasing nitrogen up to (400%N treatment) or decreasing nitrogen in the nutrient solution (50%N treatment). Regarding dry weight of the corm and pseudostem, treatments 50, 100, 200 and 400%N gave similar values without any significant differences between them. On the other hand, treatment 100%N gave the highest significant value of petioles dry weight than other treatments which gave more or less similar values. In the second season, reducing nitrogen in the nutrient solution (50% N treatment) or increasing nitrogen (400% N treatment) gave similar dry weight of different parts and total plant but these values were lesser than those of 100% and 200%N treatments which

were similar from the statistical standpoint except in petioles whereas, 200%N treatment gave the highest significant values when compared with other nitrogen treatments.

**E- Effect on chlorophyll content**

Results in (Table 8) proved that removing nitrogen from the nutrient solution gave the least significant values in any given month in the two seasons. Accordingly, plants of this treatment showed a yellowish appearance.

Generally, in the two seasons, chlorophyll content in leaf blades was increased gradually by increasing N concentration in the nutrient solution .The maximum values were obtained by (S.N.S.) treatment. More increase in the concentration of N in the nutrient solution (treatments 200%N and 400%N) gave more or less similar values but these values were lower than those of (S.N.S.) treatment, although the difference lacked significance.

Consequently, it seems that the (S.N.S.) treatment tended to give the highest value of chlorophyll content of "Williams" banana plants in the two seasons.

From the foregoing results, it could be concluded that removing nitrogen from the nutrient solution gave the lowest values of vegetative growth than those of other treatments. However, all vegetative growth parameters were gradually increased by increasing nitrogen level in the nutrient solution. The maximum increase was obtained by S.N.S. (100%N) followed closely by (200%N treatments). However, these two treatments gave similar values in most cases. On the other hand, more increase in nitrogen level (treatment 400%N) tended to reduce vegetative growth of the plant than those of the above two treatments. Thus, it seems that, nitrogen in the Standard Nutrient Solution seems to be adequate for the vegetative growth of banana plants.

In this respect, Shawky *et. al.*, (1993) proved that decreasing nitrogen by 50% or removing it from the nutrient solution of "Hindy" banana plants decreased vegetative growth but more increase in nitrogen in the nutrient solution up to (500%N) significantly increased number of green leaves per plant but other vegetative characteristics were not affected significantly.

**Table (8):- Effect of different levels of nitrogen on chlorophyll content in leaf blade of "Williams" banana plants grown in sand culture during two seasons.**

| Treatments (N%* in N.S.) | Chlorophyll content in the blade of he third leaf from the top of the plant (SPAD) value | | |
|---|---|---|---|
| | December | April | August |
| | 2005/2006 season | | |
| 0 | 31.0 c | 28.7 d | 25.7 b |
| 50 | 51.7 b | 51.0 c | 52.7 a |
| 100(S.N.S) | 55.7 a | 57.0 ab | 53.7 a |
| 200 | 51.7 b | 55.7 bc | 53.3 a |
| 400 | 51.7 b | 57.7 a | 53.7 a |
| | 2007/2008 season | | |
| 0 | 35.00c | 34.3 b | 32.0 c |
| 50 | 51.00ab | 51.7 a | 53.3 b |
| 100(S.N.S) | 52.67ab | 56.7 a | 60.0 a |
| 200 | 56.33a | 52.0 a | 55.3 ab |
| 400 | 49.67b | 53.7 a | 55.7 ab |

* N% relative to nitrogen in the Standard Nutrient Solution (S.N.S). N.S. = Nutrient Solution.
Values having the same letters in the same column in each season are not statistically different by Duncan 's multiple range test, 5% level.

**Visual symptoms of nitrogen deficiency:**

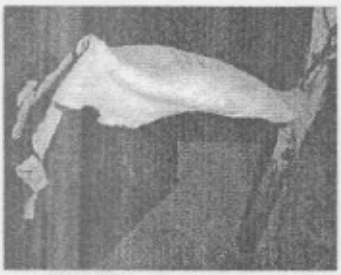
Banana plants were subjected to different levels of nitrogen in the nutrient solution from August until the next August (about 13 months). Plants of all nitrogen treatments except those of (0%N) treatment appeared healthy specially the third leaf from the top of the plant which was selected as a recommended sample for all plants.

Removing nitrogen (0%N treatment) from the nutrient solution acquired old leaves at the base of the plant a yellowish colour which covered most leaf blade leaving a narrow area with faint green colour along the midrib. During the rest of the growing season, some of these leaves became completely yellow and finally turned brown and dried. Moreover, the distance between successive leaves was reduced; giving the plant a "rosette" appearance and finally the colour of whole plant became pale green due to nitrogen deficiency (Fig.1). Under these conditions, the total number of leaves and the blade area were decreased compared with those of normal plants which were supplied with (S.N.S.) (100%N). Old leaves of other treatments supplied with

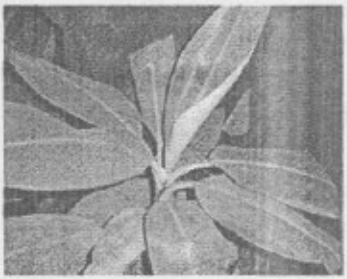
different levels of nitrogen did not show such symptoms but remained green in colour. Similar symptoms were obtained by Murray, (1959) and Shawky *et. al.*, (1993).

A- Beginning of the yellowish colour.

B- Yellowish colour covered most of leaf blade.



C- Old leaf became brown and dried.



D- "Rosette" appearance and pale green plant.

**Fig. (1). Effect of nitrogen deficiency on leaves of "Williams" banana plant.**

**Effect of different levels of nitrogen on content and uptake of nitrogen, phosphorus and potassium in different parts**

**A-1 Effect on nitrogen content:**

Results concerning nitrogen content (Table 9) proved that nitrogen percentage varied from part to another. The highest nitrogen content was in blades. On the other hand, N% was more or less similar in pseudostem, petioles and corm but roots seem to have the least N percentage. Similar results were obtained by Twyford and Walmsley (1974) who found that leaves always had the highest content of nitrogen in the vegetative phase of "Robusta" banana plants. In this respect, Shawky *et. al.*, (1974) found that the lamina of "Basrai" banana, *Musa cavendishii* had the highest nitrogen percentage, followed by the midrib whereas, the petiole had the lowest nitrogen percentage.

However, in the two seasons (Table 9), nitrogen percentage was affected significantly by the levels of nitrogen. The least significant values of nitrogen content were obtained by removing nitrogen from the nutrient solution. This was true in all parts of the plant. Increasing nitrogen level gradually in the nutrient solution increased nitrogen content gradually and the highest values were obtained by 400%N treatment.

**A- 2 Effect on nitrogen uptake:**

Regarding the distribution of nitrogen amount in different parts of plants supplied with (S.N.S.), the results as an average of the two seasons indicated that nitrogen uptake varied from part to another in the plant. The percentages of nitrogen uptake were (73.86%) in leaf blades followed in decreasing order by those in pseudostem (17.43%), petioles (3.26%), corm (3.16%) and roots (2.29%), respectively.

Accordingly, it is clear that leaf blades had the highest amount of nitrogen compared with those of any other plant part.

In the two seasons, nitrogen uptake of different parts of banana plants was affected significantly by the levels of nitrogen in the nutrient solution. In both the two seasons and in any part of the plant, the least values of nitrogen were obtained by removing nitrogen from the nutrient solution. However, a gradual increase in nitrogen uptake was obtained by increasing nitrogen level up to 100%N. Increasing nitrogen level up to 200%N, in most cases, induced a slight increase in nitrogen uptake. However, increasing nitrogen level up to 400%N did not show any particular trend where this treatment sometimes increased or decreased nitrogen uptake but in most cases treatments 100%, 200% and 400%N gave more or less similar values.

Regarding the uptake of nitrogen in total plant, in the two seasons, removing nitrogen from the nutrient solution gave the least significant values of nitrogen uptake. On the other hand, 50% N treatment induced significant increase in nitrogen uptake. More increases in nitrogen supply (100%, 200% and 400%N treatments) tended to increase nitrogen uptake but the differences between these treatments were not significant.

**Table (9):-Effect of different levels of nitrogen on content and uptake of nitrogen in different parts of "Williams" banana plants* grown in sand culture during two seasons.**

| Treatments N%** in N. S. | N% in dry matter | | | | | Uptake of nitrogen (g) / in each part | | | | | N / plant (g) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Roots | Corm | Pseudostem | Petioles | Blades | Roots | Corm | Pseudostem | Petioles | Blades | |
| | | | | | 2005/2006 season | | | | | | |
| 0 | 0.513c | 0.747d | 1.13d | 0.753e | 1.04e | 0.017d | 0.026b | 0.070d | 0.017d | 0.266c | 0.394 c |
| 50 | 0.817b | 1.10c | 1.14d | 0.893d | 2.50d | 0.114c | 0.185ab | 0.929c | 0.270c | 7.9b | 9.36 b |
| 100(S.N.S.) | 0.875b | 1.81b | 2.12c | 1.15c | 2.86c | 0.246b | 0.328a | 2.08b | 0.399b | 11.0a | 14.0 a |
| 200 | 1.11a | 1.72b | 2.63b | 1.32b | 3.09b | 0.311a | 0.265a | 2.53ab | 0.372b | 10.9a | 14.4 a |
| 400 | 1.16a | 2.25a | 3.24a | 1.90a | 4.10a | 0.203b | 0.309a | 2.70a | 0.559a | 11.6a | 15.4 a |
| | | | | | 2007/2008 season | | | | | | |
| 0 | 0.714b | 0.691d | 0.812c | 0.733c | 1.64e | 0.037c | 0.025e | 0.050c | 0.011d | 0.426b | 0.549c |
| 50 | 1.10ab | 1.14c | 1.35b | 0.887c | 2.46d | 0.178b | 0.153d | 0.719b | 0.166c | 4.3ab | 5.5 b |
| 100(S.N.S.) | 1.27a | 1.49bc | 2.08a | 1.81b | 2.81c | 0.267ab | 0.380b | 1.83a | 0.330b | 5.5a | 8.3 ab |
| 200 | 1.43a | 1.83ab | 2.08a | 2.10ab | 3.04b | 0.332a | 0.509a | 1.83a | 0.533a | 7.8a | 11.0a |
| 400 | 1.45a | 1.91a | 2.49a | 2.36a | 3.72a | 0.196b | 0.268c | 1.62a | 0.179c | 5.1a | 7.4 ab |

* Plants were 13 months old after planting ** N% relative to nitrogen in the Standard Nutrient Solution (S.N.S.). N.S. = Nutrient Solution. Values having the same letters in the same column in each season are not statistically different by Duncan 's multiple range test, 5% level.

**B-1Effect on phosphorus content:**

Phosphorus percentages in the different parts of the plant (Table 10) were more or less similar although P content in pseudostem tended to have the highest values.

In this respect, Shawky *et. al.*, (1974) found that the lamina of "Basrai" banana, *Musa cavendishii* had the highest phosphorus percentage followed by the midribs and petioles.

Generally, phosphorus content in different parts of the plant (Table 10) seems to be affected significantly by nitrogen levels. However, the effect varied from season to season. In the first season, the least values of phosphorus in roots, pseudostem and blades were obtained by removing nitrogen or the extremely supply of nitrogen in the nutrient solution (400%N treatment). However, phosphorus concentrations in petioles were not affected by nitrogen level in the nutrient solution.

In the second season, it is observed that phosphorus content in different parts of the plant was not affected significantly by nitrogen treatments.

**B-2 Effect on phosphorus uptake:**

Regarding the distribution of phosphorus in different parts of plants supplied with (S.N.S.) (Table 10), the results as an average of the two seasons indicated that phosphorus uptake varied from part to another in the plant. The percentages of phosphorus uptake were 61.72%, 25.16%, 5.06%, 4.07% and 3.99 % in blades, pseudostem, petioles, corm and roots, respectively. This proves that blades had the highest amount of phosphorus in the plant.

In both seasons, the least values of phosphorus uptake in different parts of the plant were obtained by removing nitrogen from the nutrient solution. The effect of other treatments varied from season to season. In the first season, the highest values of phosphorus were obtained by 100%N treatment. Increasing nitrogen level up to 200%N gave more or less similar values as those of 100%N treatment. However, more increase in nitrogen level in the nutrient solution reduced phosphorus uptake in the different parts of the plant.

In the second season, treatment (200%N) gave the highest uptake of phosphorus followed by those of the 100%N treatment although these two treatments were similar from the statistical standpoint. However, reducing or increasing nitrogen level reduced phosphorus content than the above two treatments.

Consequently, it could be concluded that the uptake of phosphorus in total plant in the two seasons was affected by treatments. Removing nitrogen from the nutrient solution gave the least significant values of phosphorus uptake. However, phosphorus uptake was increased gradually by increasing nitrogen concentration in the nutrient solution up to 100%N. Thereafter, phosphorus uptake was decreased gradually by treatments 200, 400%N. In other words, phosphorus uptake reached the maximum by treatment 100%N. Decreasing or increasing nitrogen level reduced phosphorus uptake. In other words, it could be concluded that the S.N.S. gave the highest phosphorus uptake.

**Table (10):-Effect of different levels of nitrogen on content and uptake of phosphorus in different parts of "Williams" banana plants* grown in sand culture during two seasons.**

| Treatments N%** in N.S. | P% in dry matter | | | | | Uptake of phosphorus (g) / in each part | | | | | P / plant (g) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Roots | Corm | Pseudostem | Petioles | Blades | Roots | Corm | Pseudostem | Petioles | Blades | |
| | | | | | 2005/2006 season | | | | | | |
| 0 | 0.243e | 0.223b | 0.513c | 0.313a | 0.280e | 0.008d | 0.008a | 0.032c | 0.007e | 0.073d | 0.128d |
| 50 | 0.363a | 0.250b | 0.540b | 0.360a | 0.297d | 0.051c | 0.042a | 0.439ab | 0.109b | 0.935c | 1.58c |
| 100(S.N.S.) | 0.350b | 0.360a | 0.540b | 0.343a | 0.390a | 0.098a | 0.065a | 0.530a | 0.119a | 1.50a | 2.31a |
| 200 | 0.320c | 0.417a | 0.577a | 0.367a | 0.320b | 0.090b | 0.064a | 0.555a | 0.103c | 1.13b | 1.94b |
| 400 | 0.290d | 0.360a | 0.467d | 0.307a | 0.307c | 0.051c | 0.049a | 0.389b | 0.090d | 0.868c | 1.46c |
| | | | | | 2007/2008 season | | | | | | |
| 0 | 0.265a | 0.297a | 0.366a | 0.276a | 0.358a | 0.014c | 0.011b | 0.029c | 0.004c | 0.091b | 0.149c |
| 50 | 0.203a | 0.273a | 0.380a | 0.302a | 0.363a | 0.033b | 0.037b | 0.202b | 0.056b | 0.639a | 0.966b |
| 100(S.N.S.) | 0.203a | 0.310a | 0.399a | 0.332a | 0.346a | 0.043ab | 0.079a | 0.350a | 0.060ab | 0.683a | 1.22ab |
| 200 | 0.224a | 0.341a | 0.399a | 0.333a | 0.415a | 0.052a | 0.095a | 0.352a | 0.085a | 1.06a | 1.64a |
| 400 | 0.224a | 0.312a | 0.382a | 0.358a | 0.405a | 0.030b | 0.044b | 0.249b | 0.027c | 0.555ab | 0.904b |

* Plants were 13 months old after planting ** N% relative to nitrogen in the Standard Nutrient Solution (S.N.S.). N.S. = Nutrient Solution.
Values having the same letters in the same column in each season are not statistically different by Duncan 's multiple range test, 5% level.

### C-1 Effect on potassium content:

Results in (Table 11) showed that potassium content in the two seasons varied from organ to another. The highest K percentages were existed in pseudostem followed closely by that in the petioles. Blades and corms gave more or less similar values although K content tended to be higher in corms in the first season but in the second season K% in blades was higher than that of corms. However, in the two seasons, roots had the least K content.

In this respect Shawky *et. al.*, (1974) found that potassium percentage in petiole or midrib was twice as much as that in lamina in "Basrai" banana.

Regarding the effect of nitrogen treatments on potassium content in different plant parts (Table 11), it seems that potassium content was affected significantly by the levels of nitrogen. Removing nitrogen from the nutrient solution gave the highest significant values of K content in all parts except pseudostem and blades. On the other hand, the least significant values of potassium content in most parts of the plant were obtained by the highest level of nitrogen in the nutrient solution (400%N) except in the pseudostem and blades. Other

treatments had no effect on potassium content in different parts since most values were more or less similar from the statistical standpoint.

**C-2 Effect on potassium uptake:**

Regarding the distribution of potassium in different parts of plants supplied with (S.N.S.), (Table 11) the results as an average of the two seasons indicated that potassium uptake varied from part to another in the plant. The percentages of potassium uptake were 50.07%, 35.80%, 8.37%, 3.37%and 2.40% in blades, pseudostem, petioles, corm and roots, respectively. Consequently, the highest amount of potassium in the plant is existed in blades.

In the two seasons, potassium content in different parts of the plant was affected significantly by the levels of nitrogen in nutrient solution. The least significant values were obtained by removing nitrogen from the nutrient solution. However, other treatments behaved diversely from season to season. In the first season, the highest potassium uptake in different plant parts was obtained by 100%N treatment. Decreasing nitrogen in the nutrient solution (50% N treatment) reduced potassium uptake in different parts. On the other hand, there was a gradual decrease in potassium uptake in different parts of plant by the gradual increase of nitrogen concentration in the nutrient solution. In other words, the excess of nitrogen in the nutrient solution tended to reduce potassium uptake in the different parts of the plant.

In the second season, treatments 100%N and 200%N gave the highest but insignificant increase in potassium uptake in the different parts of the plant. On the other hand, treatment (50%N) gave similar or slight lower values of potassium uptake when compared with the above two treatments. The excess of nitrogen in the nutrient solution (400%N treatment) tended to decrease potassium uptake than those of the above three treatments.

Regarding the uptake of potassium in total plant, in the two seasons, removing nitrogen from the nutrient solution gave the least significant values of K uptake. Whereas, the uptake was increased gradually by increasing nitrogen in the nutrient solution and the highest values were obtained by 100%N treatment in the first season and by treatment 200%N in the second season although the difference between the two treatments was not significant. More increase in nitrogen concentration (400%N treatment) reduced potassium uptake.

**Table (11):-Effect of different levels of nitrogen on content and uptake of potassium in different parts of "Williams" banana plants* grown in sand culture during two seasons.**

| Treatments N%** in N. S. | K% in dry matter | | | | | Uptake of potassium (g) / in each part | | | | | K/ plant (g) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Roots | Corms | Pseudostem | Petioles | Blades | Root | Corm | Pseudostem | Petioles | Blades | |
| | | | | | 2005/2006 season | | | | | | |
| 0 | 2.36a | 3.06a | 4.96b | 6.13a | 2.04a | 0.078d | 0.104b | 0.308c | 0.135c | 0.529c | 1.15c |
| 50 | 2.09ab | 2.69ab | 5.99a | 5.81a | 2.33a | 0.293bc | 0.451a | 4.87b | 1.76a | 7.34ab | 14.7 b |
| 100(S.N.S.) | 1.85ab | 2.68ab | 6.20a | 5.18b | 2.70a | 0.520a | 0.486a | 6.08a | 1.80a | 10.38a | 19.3 a |
| 200 | 1.73ab | 2.51b | 6.00a | 5.10b | 2.04a | 0.485ab | 0.386a | 5.77ab | 1.43b | 7.19ab | 15.3 b |
| 400 | 1.38b | 2.46b | 5.80a | 4.93b | 2.01a | 0.241cd | 0.338ab | 4.83ab | 1.45b | 5.69b | 12.5 b |
| | | | | | 2007/2008 season | | | | | | |
| 0 | 1.83a | 2.98a | 5.29b | 6.31a | 2.91a | 0.095b | 0.109c | 0.423c | 0.098b | 0.757b | 1.49d |
| 50 | 1.84a | 2.60b | 6.11a | 5.75b | 2.99a | 0.297a | 0.349b | 3.25b | 1.07a | 5.25ab | 10. 2bc |
| 100(S.N.S.) | 1.26b | 2.40c | 6.39a | 5.13c | 3.07a | 0.264a | 0.613a | 5.61a | 0.933a | 6.08a | 13.5ab |
| 200 | 1.23b | 2.35c | 6.20a | 4.70cd | 2.70a | 0.286a | 0.651a | 5.47a | 1.19a | 6.91a | 14.5a |
| 400 | 1.12b | 2.30c | 5.95ab | 4.39d | 2.65a | 0.152b | 0.323b | 3.88b | 0.333b | 3.62ab | 8.3c |

* Plants were 13 months old after planting ** N% relative to nitrogen in the Standard Nutrient Solution (S.N.S.). N.S. = Nutrient Solution.
Values having the same letters in the same column in each season are not statistically different by Duncan 's multiple range test, 5% level.

**Effect of different levels of nitrogen and sampling date on mineral content in leaf blades.**

**A- Effect on nitrogen:**

**Effect of nitrogen level:** In the two seasons (Table 12) nitrogen content was affected significantly by the levels of nitrogen in the nutrient solution. Generally, treatment (400%) gave the highest values of nitrogen content followed in decreasing order by those of (200%), (100%), (50%) and (0%) treatments, respectively.

**Effect of sampling date:** In the two seasons, nitrogen content was affected significantly by the time of sampling. Although samples were taken from leaves of similar age, the highest significant values were obtained by sample taken in August in the two seasons. On the other hand, samples taken in December or April gave similar values but they were lower than that of August.

**The interaction between nitrogen level and sampling date:** This interaction was significant in the two seasons. Removing nitrogen gave the lowest significant values of nitrogen content in any given month in both the two seasons.

In general, nitrogen content for any given treatment remained stable on any sampling date except those of (400%N treatment) where nitrogen content was lowest in December sample and increased gradually in April and August samples. This was true in both the two seasons.

Depending upon the results of the interaction in the two seasons, it could be safely concluded that nitrogen content in leaf blades, ranged between 1.04-1.64% due to removing nitrogen from the nutrient solution. This range means lack (deficiency) of nitrogen. However, nitrogen content was increased and ranged between 2.46-2.67% in leaf blades when plants were supplied with 50%N in nutrient solution. This means that nitrogen is low. Nitrogen content in leaf blades in plants supplied with Standard Nutrient Solution ranged between 2.76-2.86%. This means that nitrogen is optimum. Increasing nitrogen supply up to 200%N, increased nitrogen content and the percentage of nitrogen ranged between 2.85-3.09%. This means that nitrogen is high. More increase in nitrogen supply increased nitrogen content and ranged between 3.07-4.10% .This could be considered that nitrogen is very high or in excess.

The foregoing data showed that, when removing nitrogen from the nutrient solution the nitrogen content in leaf blades decreased by about 52% when compared with plants supplied with (S.N.S.).

These results are in agreement with those obtained by Murray, (1960) who found that nitrogen in leaves of different ages of the banana "Dwarf Cavendish" grown in sand culture was very low in nitrogen deficient plants. Whereas, Shawky *et. al.*, (1993) found that when removing nitrogen from the nutrient solution, the content of nitrogen in the third leaf from the top of "Hindy" banana plants attained 0.63-1.17%, this means a lack of nitrogen but N content ranged between 1.99-2.62% when plants were supplied with the Standard Nutrient Solution. The excess of N in the nutrient solution (500% N treatment) increased nitrogen up to a highest value (4.22%).

**B- Effect on phosphorus:**

**Effect of nitrogen level:** In the first season, phosphorus content (Table 12) was affected significantly by nitrogen treatment. There was a gradual increase in phosphorus content by increasing nitrogen level in the nutrient solution. Treatments 100, 200 and 400% N gave similar values which were significantly higher than those of 0% and 50% N treatments.

**Table (12):-Effect of different levels of nitrogen and sampling date on N, P and K content in leaf blades of "Williams" banana plants grown in sand culture during two seasons.**

| Treatments | N % in dry matter | | | | P % in dry matter | | | | K % in dry matter | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N%* in N.S. | Dec. | April. | Aug. | Mean | Dec. | April. | Aug. | Mean | Dec. | April. | Aug. | Mean |
| | | | | | | 2005/2006 season | | | | | | |
| 0 | 1.30i | 1.09j | 1.04j | 1.14E' | 0.253c | 0.267c | 0.280c | 0.267B' | 2.38ab | 2.36ab | 2.04bc | 2.26A' |
| 50 | 2.50h | 2.59h | 2.49h | 2.53D' | 0.260c | 0.300c | 0.297c | 0.286B' | 2.40ab | 1.88bc | 2.33ab | 2.20AB' |
| 100(S.N.S.) | 2.77g | 2.79g | 2.86fg | 2.81C' | 0.300c | 0.317bc | 0.390ab | 0.336A' | 2.41ab | 1.86bc | 2.70a | 2.33A' |
| 200 | 2.96ef | 3.00de | 3.09cd | 3.01B' | 0.300c | 0.390ab | 0.320bc | 0.337A' | 2.12abc | 1.56c | 2.04bc | 1.91BC' |
| 400 | 3.12c | 3.27b | 4.10a | 3.50A' | 0.257c | 0.453a | 0.307c | 0.339A' | 2.03bc | 1.54c | 2.01bc | 1.86C' |
| Mean | 2.53B | 2.55B | 2.72A | | 0.274B | 0.345A | 0.319A | | 2.27A | 1.84B | 2.23A | |
| | | | | | | 2007/2008 season | | | | | | |
| 0 | 1.11j | 1.32i | 1.64h | 1.36E' | 0.218d | 0.233d | 0.358a-c | 0.270B" | 2.58a-d | 2.34c-e | 2.91a-c | 2.61AB' |
| 50 | 2.67ef | 2.61f | 2.46g | 2.85D' | 0.235d | 0.266cd | 0.363a-c | 0.288AB | 2.94ab | 2.57a-d | 2.99a | 2.83A' |
| 100(S.N.S.) | 2.80de | 2.76de | 2.81de | 2.79C' | 0.261cd | 0.281cd | 0.346a-c | 0.296AB' | 2.83a-c | 2.34c-e | 3.07a | 2.75AB' |
| 200 | 2.85d | 2.87d | 3.04c | 2.92B' | 0.280cd | 0.304b-d | 0.415a | 0.333A' | 2.34c-e | 2.37b-e | 2.70a-d | 2.47BC' |
| 400 | 3.07c | 3.22b | 3.72a | 3.34A' | 0.287cd | 0.302cd | 0.405ab | 0.331A' | 2.21de | 1.92e | 2.65a-d | 2.26C' |
| Mean | 2.50B | 2.55B | 2.73A | | 0.256B | 0.277B | 0.377A | | 2.58B | 2.31C | 2.86A | |

* N% relative to nitrogen in the Standard Nutrient Solution (S.N.S.). N.S. = Nutrient Solution.
Means of each of treatments, months or their interactions in each season having the same letters are not statistically different by Duncan multiple range test, 5% level

In the second season, there was a gradual increase in phosphorus content by increasing nitrogen level in the nutrient solution. However, there were no significant differences among treatments.

In this respect, Murray, (1960) found that nitrogen deficiency of "Dwarf Cavendish" banana grown in sand culture, increased phosphorus content. On the contrary, Shawky *et. al.*, (1993) found that removing or decreasing nitrogen in the nutrient solution decreased phosphorus content in leaf blades of "Hindy" banana plants grown in sand culture but increasing nitrogen in the nutrient solution increased P content in leaf blades.

**Effect of sampling date:** In the two seasons (Table 12), phosphorus content was affected significantly by date of sampling. In both seasons, sampling in December gave the least values but the effect varied from season to season. In the first season, phosphorus content was similar in samples of April and August but these values were significantly higher than that of December. In the second season, sampling in August gave the highest significant value of phosphorus whereas phosphorus content was similar in December and April samples.

It could be conclude that, the highest values of phosphorus content were obtained when samples were taken in April or August.

**The interaction between nitrogen level and sampling date:** Results in (Table 12) revealed that the interaction was significant in the two seasons. In the first season, the values of phosphorus were similar for all treatments except those of 100% N in August, 200% N and 400%N in April which were significantly higher than those of other treatments.

In the second season, all treatments gave more or less similar values except treatments 200%N and 400%N in August which gave the highest significant values compared with other treatments. However, the results of the two seasons clearly indicate that phosphorus content was more or less similar for most treatments. This is expected because all plants received similar amount of phosphorus in the nutrient solution.

**C- Effect on potassium:**

**Effect of nitrogen levels:** Values of potassium content in the two seasons (Table 12), were significantly affected by treatments. In the two seasons, treatments 0, 50 and 100%N gave similar values however, these values were higher than those of 200 and 400%N treatments. In other words, it seems that the increase of nitrogen in nutrient solution decreased potassium content significantly and the highest nitrogen level 400% gave the least potassium value. On the contrary, potassium content was not affected when nitrogen level was 0, 50 or 100%N in the nutrient solution.

In this respect, Shawky *et. al.*, (1993) found that decreasing nitrogen in the nutrient solution reduced K content. Removing nitrogen had inconsistent effect on K content but increasing nitrogen increased K content in leaf blades of "Hindy" banana plants grown in sand culture.

**Effect of sampling date:** In the two seasons, potassium content (Table 12) was affected significantly by date of sampling. In the first season, potassium content in samples of December and August were similar but they were higher than that of April. In the second season, potassium content in samples of, August was the highest followed in decreasing order by those of December and April samples, respectively.

It could be concluded that, the highest values of potassium content were obtained in August sample.

**The interaction between nitrogen level and sampling date**: The interaction was significant in the two seasons. Most treatments gave similar potassium values on any given date in each season and treatment 100%N in August gave the highest values in the two seasons.

Generally, from the foregoing results about the effect of nitrogen level and sampling date on N, P and K, it could be concluded that although plants were in the vegetative phase, but sampling date had a pronounced effect on mineral content although these leaves had similar age. Therefore, it seems that leaves collected in December (when plants were four months old after planting) had lower nutrients content than those sampled in April (when plants were eight months old after planting). Leaves collected in August (when plants were thirteen months old after planting) gave the highest nutrients values.

Consequently, it could be safely concluded that date of collection had a decisive role on mineral content of leaf although leaves were of the same age. In other word, samples collected in early stage of vegetative phase had lower mineral content than those collected in the middle stage of the vegetative phase whereas, those collected in the later stage of vegetative phase had the highest values. These variations may be due to the environmental conditions during this period which were suitable to maximize growth and absorption of nutrients. No doubt the physiology of the plant was affected by age of the plant itself and consequently the mineral content of different leaf samples would be affected. For example, the characters of leaves, petioles, pseudostem corms and roots varied from date to date and consequently the metabolic activity of each part will be affected which one way or another will affect mineral content. Therefore, sampling date should be put in consideration if we are looking for a proper sampling from banana plant.

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# تأثير المستويات المختلفة من النتروجين على النمو الخضرى و المحتوى المعدنى وامتصاص العناصر الغذائية لنباتات موز الوليامز النامية فى مزرعة رملية

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أجريت هذه الدراسة خلال موسمي 2006/2005 – 2008/2007 على نباتات الموز صنف وليامز ناتج زراعة الانسجة و النامية فى مزرعة رملية تحت صوبة بلاستيكية بكلية الزراعة جامعة عين شمس بشـبرا الخيمة. و ذلك بهدف دراسة تأثير المستويات المختلفة من النتروجـين فى المحلول الغذائى على النمو والمحـــتوى المعدنى و امتصاص العناصر لنباتات الموز و اشتمل البحث على خمسة معاملات وهى ( 0% ، 50%، 100%، 200، 400% ن) من النتروجين فى المحلول الغذائى

- أدى ازالة النتروجين من المحلول الغذائى الى نقص النمو الخضرى و ظهور انواع مختلفة من الاصـفرار علـى الاوراق المسنة خاصـة تلـك التـى عند قاعدة السـاق الكاذبـة ، فـى حـين أدت زيـادة النتروجين الـى زيـادة معنويـة فـى النمو الخضرى (قطـر اللساق- عـدد الاوراق- مساحة الورقـة – الكلورفيل- الوزن الطازج و الجـاف للنبات) لتعطـى المعاملة (100% ن) أعلى القيم ولكن استمرار الزيادة فى تركيز النتروجين (200%، 400% ن) قللت النمو الخضرى للنبات.

- عنـد دراسـة توزيـع النتروجين فـى الاعضاء المختلفـة و ذلـك فـى النباتـات المعاملـة بـالمحلول الغـذائى القياسـى فقـد وجـد أن أنـصال الاوراق تحتـوى علـى أعلـى كميـة مـن النتـروجين الممـتص (73.86%) ويليها الساق الكاذبة ،الاعناق ، الكورمـة و اخيرا الجذور حيث كانت النسب 17.43، 3.26، 3.16، 2.29 % علـى التوالى. وعلـى ذلـك يتـضح ان النـصل يحتـوى علـى أعلـى كميـة مـن النتروجين و هذا يؤكد أن نصل الورقة الثالثة من قمة النبات هو أنسب نسيج لتقدير النتروجين بالنبات.

-كذلك أتضح أن عينات أنصال الاوراق التى أخذت بعمر واحد و لكن فى مواعيد مختلفة بهدف تحليل العناصر بها فقد ثبت أن العينات المأخوذة فى نهـاية الموسـم (أغسطس) كانت ذات نسب أعلى من عـناصر النتروجـــين و الفوسفور و البوتاسيوم عن تلك المأخوذة فى أشـهر ديسمبر أو ابريل و من ذلك يتضح أهمية تأثير ميعاد أخذ العينة على محتوى نصل الورقة من العناصر.

- عند ازالة النتروجين من المحلول الغذائى تراوحت نسبة النتروجين فى نصل الورقة الثالثة من أعلى النبات من (1.04-1.64) و كان ذلك دليلا على المستوى المنخفض جدا (حد النقص) و فى حين أن النباتات المعاملة بـ 50% من تركيز النتروجين فى المحلول القياسى فقد تراوحت نسبة النتروجين مابين (2.46- 2.67%) ويمثل هذا المستوى المنخفض للنتروجين فى أنصال الاوراق . أما النباتات التى عوملت بالمحلول الغذائى القياسى فتراوحت نسبة النتروجين فى أنصال الاوراق ما بين (2.76-2.86%) ويمثل هذا المستوى الامثل للنـتروجين فـى أنصـال الاوراق و عند زيـادة النتروجين فـى المحلول الغذائى الى 200% من تركيز النتروجين فى المحلول القياسى فقد وصلت نسبته الى (2.85-3.09%) فى أنصال الاوراق و يمثل هذا المستوى العالى للنتروجين فى الاوراق.ومع زيادة تركيز النتروجين فى المحلول الغذائى الى 400 % من تركيز النتروجين فى المحلول القياسى وصلت النسبة الى (3.07-4.10%) و يمثل هذا المستوى المرتفع جدا للنتروجين فى أنصال الاوراق.

-بالنسبة لتأثير معاملات النتروجين على العناصر الاخرى فقد أدى ازالة أو نقص النتروجين من المحلول الغذائى الى نقص النتروجين و الفوسفور بينما زاد محتوى البوتاسيوم فـى أنصال الاوراق و مع زيادة مستوى النتروجين فـى المحلول الغذائى حدثت زيـادة تدريجية فـى محتوى الفوسفور بينما أعطت المعاملة (400% نتروجين) أقل محتوى للبوتاسيوم فى أنصال الاوراق.