# 4. RESULTS AND DISCUSSION

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## 4.1. FIRST EXPERIMENT:

**Effect of level and source of N fertilizer on growth, chemical composition, yield and fruit quality of tomato.**

### 4.1.1. Vegetative growth.

#### 4.1.1.1. Effect of nitrogen source on vegetative growth of tomato plant at flowering stage.

Data presented in Table ( 1 ) show the effect of nitrogen source on vegetative growth of tomato plant at flowering stage expressed as plant height, number of leaves or branches per plant, fresh and dry weights of plant foliage in the early summer season of both 1993 and 1994. Data showed that number of leaves or branches per plant, dry weight of leaves and total dry weight per plant were not significantly affected by N-source in both seasons. However, urea application led to a significant increase in fresh weight of leaves and / or branches only in the first season. An opposite trend was detected in the second season, whereas ammonium nitrate increased fresh weight of branches as compared with urea.

The similar effect of both urea and ammonium nitrate on tomato plant vegetative growth may be due to that urea behavies like ammonium source of nitrogen after hydrolysis added to that ammonium nitrate contains 50 % of its nitrogen in the $NH_4$-form. Moreover, most of the previous studies mentioned that the adverse effect of urea on plant growth depended on the quick hydrolysis of urea and the high release of active ammonium ions in the soil solution and consequently in plant tissues especially when plants were grown in sandy soil ( Gabal, 1983 and Magalhaes and Wilcox, 1984 ).

**Table (1): Vegetative growth of tomato plants, at flowering stage as affected by source or level of nitrogen fertilizer during the seasons of 1993 and 1994.**

**Early summer season, 1993**

| Treatments | Plant ht. Cm. | No. of leaves / plant | No. of branches / plant | Fresh weight ( g / plant ) | | | Dry weight ( g / plant ) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | leaves | branches | total | leaves | branches | total |
| **N-source** | | | | | | | | | |
| Urea | 36.22 | 19.50 | 1.75 | 19.08 | 5.98 | 25.06 | 3.49 | 1.72 | 5.21 |
| Amm. nitrate | 35.44 | 19.61 | 1.63 | 16.57 | 5.44 | 22.01 | 3.20 | 1.55 | 4.75 |
| **L.S.D. at 0.05** | **N.S.** | **N.S.** | **N.S.** | **1.62** | **0.51** | **1.88** | **N.S.** | **0.17** | **N.S.** |
| **Kg N/fed.** | | | | | | | | | |
| 0 | 37.83 | 17.66 | 1.66 | 15.63 | 4.73 | 20.36 | 2.98 | 1.35 | 4.33 |
| 60 | 33.41 | 17.58 | 1.58 | 17.12 | 5.20 | 22.32 | 3.32 | 1.48 | 4.80 |
| 120 | 38.41 | 21.33 | 1.75 | 19.34 | 6.01 | 25.35 | 3.62 | 1.72 | 5.34 |
| 180 | 36.00 | 21.16 | 1.83 | 20.66 | 6.79 | 27.45 | 3.86 | 1.95 | 5.81 |
| 240 | 33.50 | 19.16 | 1.66 | 17.01 | 5.75 | 22.76 | 3.24 | 1.63 | 4.87 |
| 300 | 35.83 | 20.41 | 1.66 | 17.21 | 5.77 | 22.98 | 3.06 | 1.67 | 4.73 |
| **L.S.D. at 0.05** | **N.S.** | **N.S.** | **N.S.** | **2.81** | **0.93** | **3.25** | **N.S.** | **0.29** | **N.S.** |

**Early summer season, 1994**

| Treatments | Plant ht. Cm. | No. of leaves / plant | No. of branches / plant | Fresh weight ( g / plant ) | | | Dry weight ( g / plant ) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | leaves | branches | total | leaves | branches | total |
| **N-source** | | | | | | | | | |
| Urea | 35.10 | 41.63 | 4.52 | 70.83 | 31.97 | 102.80 | 11.00 | 4.27 | 15.27 |
| Amm. nitrate | 37.38 | 42.11 | 4.75 | 74.61 | 36.19 | 110.80 | 10.71 | 4.65 | 15.36 |
| **L.S.D. at 0.05** | **2.03** | **N.S.** | **N.S.** | **N.S.** | **4.05** | **N.S.** | **N.S.** | **N.S.** | **N.S.** |
| **Kg N/fed.** | | | | | | | | | |
| 0 | 34.50 | 31.00 | 4.83 | 56.86 | 23.77 | 80.63 | 8.35 | 3.26 | 11.61 |
| 60 | 39.08 | 40.75 | 4.83 | 73.05 | 34.28 | 107.33 | 10.13 | 4.30 | 14.43 |
| 120 | 38.00 | 46.41 | 4.16 | 78.96 | 40.50 | 119.49 | 11.91 | 5.11 | 17.02 |
| 180 | 35.61 | 47.58 | 4.75 | 84.42 | 42.43 | 126.85 | 13.20 | 5.44 | 18.64 |
| 240 | 35.91 | 43.91 | 4.66 | 70.72 | 31.67 | 102.39 | 10.68 | 4.27 | 14.95 |
| 300 | 34.35 | 41.58 | 4.58 | 72.30 | 31.84 | 104.14 | 10.90 | 4.38 | 15.28 |
| **L.S.D. at 0.05** | **N.S.** | **10.45** | **N.S.** | **12.91** | **7.02** | **13.57** | **1.95** | **0.99** | **2.30** |

Added to that the adverse effect of heavy urea application on plant growth was less detected when tomato grown in clay loam soil ( Gabal et al, 1990 ). Therefore, urea may had similar effect on plant growth equal to that of $NH_4$ $NO_3$ especially this work was done in a clay loam soil and growth was evaluated at flowering time and N-fertilizer including urea was added at 3 equal times. Sampling plants for plant growth evaluation was carried out at 30 and 10 days after 1$^{st}$ and 2$^{nd}$ time of nitrogen fertilizer application which may give enough chance for nitrification.

### 4.1.1.2. Effect of N-level on vegetative growth of tomato plant at flowering stage.

Data in Table ( 1 ) showed that plant height and number of branches per plant were not considerably affected by increasing level of nitrogen application in both seasons. Number of leaves per plant was also not affected by increasing level of nitrogen application in the first season, however in the second one. N-application encouraged plant growth than the control with no significant differences between N-levels from 60 up to 300 kg N/fed.

With respect to total fresh weight of leaves and / or branches, they were increased significantly by increasing level of nitrogen application from 0 up to 120 Kg N/fed. Increasing level of N-fertilizer from 120 up to 180 Kg N/fed. had no significant effect on plant growth. However, heavier applications of nitrogen at 240 and 300 Kg N/fed. depressed plant growth.This trend was detected in both seasons of 1993 and 1994.

With respect to plant dry weight the same trend of fresh weight was detected but variances were only significant in one season. It was clear that all levels of N-application increased plant growth expressed as fresh or dry weight of leaves and /or branches than the control. Whereas, increasing level of

N-fertilizer from 0 up to 120 Kg N/fed. gradually increased dry weight of leaves, branches and total plant foliage however, no significant differences in plant dry weight were found between 120 and 180 Kg N/fed. Moreover, heavier application of N-fertilizer up to 240 or 300 Kg N/fed. decreased plant growth expressed as fresh or dry weight of leaves and / or branches as compared with the lower N-levels.

This favorable effect of N-application on plant growth may be due to the vital role of nitrogen on the synthesis of plant proteins, chlorophyll and enzymes. This result is in agreement with Famous and Bautista ( 1983 ); kooner and Randhawa ( 1983 ); Grela Larenzo et al ( 1988 ) and Suniaga et al ( 1992 ) on tomato. Of course if nitrogen is added at high levels more than the maximum level ( 120 - 180 Kg N/fed. ) the depression effect of fertilizer on plant growth should be expected. However many investigators mentioned adverse effects of heavy N-application on plant growth ( Doss et al, 1975; Grela Larenzo et al, 1988; El-Aela, 1988 and Chung et al, 1992 ).

### 4.1.1.3. Effect of N-source within N-level on vegetative growth of tomato plant at flowering stage.

Data Table ( 2 ) showed that N-source within N-level had no significant effect on plant height, number of leaves or branches, fresh and dry weight of plant foliage in both season. This trend may be attributed to that the two used sources of nitrogen; $NH_4 NO_3$ and urea had similar properties. Urea is converted to $NH_4$-N after hydrolysis and $NH_4 NO_3$ is ionized to 50 % $NH_4^+$ and 50 % $NO_3$- after soil application. Added to that the adverse effect of heavy urea application was not considerably detected under such conditions of the clay loam soil of the experiment, especially plants were grown in early summer season. Therefore, the interaction effect of these two factors ( levels and forms ) was not significant as shown in Table ( 2 ) as a general trend for both seasons.

**Table (2): Vegetative growth of tomato plants, at flowering stage ( 50days after transplanting, first sample ) as affected by N-source within N-level, during the early summer seasons of 1993 and 1994.**

**Early summer season, 1993**

| Treatments | | Plant ht. | No. of leave | No. of branche | Fresh weight ( g / plant ) | | | Dry weight ( g / plant ) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| N-source | Kg N/fed. | Cm. | / plant | / plant | leaves | branches | total | leaves | branches | total |
| Urea | 0 | 37.83 | 17.66 | 1.66 | 15.63 | 4.73 | 20.36 | 2.98 | 1.35 | 4.33 |
| | 60 | 33.67 | 18.00 | 1.50 | 18.95 | 5.56 | 24.51 | 3.71 | 1.59 | 5.30 |
| | 120 | 39.66 | 21.50 | 1.83 | 20.24 | 6.31 | 26.55 | 3.78 | 1.82 | 5.60 |
| | 180 | 37.33 | 20.33 | 1.83 | 23.03 | 7.66 | 30.69 | 4.18 | 2.19 | 6.37 |
| | 240 | 32.16 | 19.50 | 1.83 | 18.06 | 5.81 | 23.87 | 3.32 | 1.66 | 4.98 |
| | 300 | 36.66 | 20.00 | 1.83 | 18.60 | 5.76 | 24.36 | 2.99 | 1.72 | 4.71 |
| Amm. nitrate | 0 | 37.83 | 17.66 | 1.66 | 15.63 | 4.73 | 20.36 | 2.98 | 1.35 | 4.33 |
| | 60 | 33.16 | 17.16 | 1.66 | 15.29 | 4.84 | 20.13 | 2.93 | 1.37 | 4.30 |
| | 120 | 37.16 | 21.16 | 1.66 | 18.45 | 5.72 | 24.17 | 3.46 | 1.61 | 5.07 |
| | 180 | 24.67 | 22.00 | 1.83 | 18.29 | 5.91 | 24.20 | 3.54 | 1.72 | 5.26 |
| | 240 | 34.83 | 18.83 | 1.50 | 15.97 | 5.69 | 21.66 | 3.16 | 1.61 | 4.77 |
| | 300 | 35.00 | 20.83 | 1.50 | 15.83 | 5.78 | 21.61 | 3.13 | 1.62 | 4.75 |
| **L.S.D. at 0.05** | | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** |

**Early summer season, 1994**

| Treatments | | Plant ht. | No. of leave | No. of branche | Fresh weight ( g / plant ) | | | Dry weight ( g / plant ) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| N-source | Kg N/fed. | Cm. | / plant | / plant | leaves | branches | total | leaves | branches | total |
| Urea | 0 | 34.50 | 31.00 | 4.83 | 56.86 | 23.77 | 80.63 | 8.35 | 3.26 | 11.61 |
| | 60 | 38.10 | 40.16 | 5.16 | 69.60 | 29.73 | 99.33 | 9.88 | 3.84 | 13.72 |
| | 120 | 35.90 | 46.66 | 3.83 | 73.40 | 34.81 | 108.21 | 12.02 | 4.85 | 16.87 |
| | 180 | 35.50 | 47.66 | 4.50 | 79.89 | 37.17 | 117.06 | 13.25 | 5.05 | 18.30 |
| | 240 | 33.16 | 43.50 | 4.16 | 71.58 | 32.88 | 104 46 | 11.00 | 4.14 | 15.14 |
| | 300 | 33.46 | 40.80 | 4.66 | 73.64 | 33.46 | 107.10 | 11.57 | 4.51 | 16.08 |
| Amm. nitrate | 0 | 34.50 | 31.00 | 4.83 | 56.86 | 23.77 | 80.63 | 8.35 | 3.26 | 11.61 |
| | 60 | 40.06 | 41.33 | 4.50 | 76.50 | 38.82 | 115.32 | 10.39 | 4.77 | 15.16 |
| | 120 | 40.10 | 46.16 | 4.50 | 84.52 | 46.20 | 130.72 | 11.82 | 5.38 | 17.20 |
| | 180 | 35.73 | 49.50 | 5.00 | 88.95 | 47.69 | 136.64 | 13.15 | 5.84 | 18.99 |
| | 240 | 38.66 | 44.30 | 5.16 | 69.86 | 30.47 | 100.33 | 10.36 | 4.40 | 14.76 |
| | 300 | 35.23 | 42.30 | 4.50 | 70.96 | 30.22 | 101.18 | 10.23 | 4.26 | 14.49 |
| **L.S.D. at 0.05** | | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** |

## 4.1.1.4. Effect of nitrogen source on vegetative growth of tomato plant at fruit setting stage.

Data Table ( 3 ) showed that N-source had no significant effect on plant height and number of branches per plant in both seasons. However, number of leaves increased slightly by urea application as compared with ammonium nitrate in both seasons. With respect to fresh weight of leaves it was not significantly affected by N-source in both seasons. Fresh weight of branches was increased by urea application in the first season, but an opposite trend was detected in the second one.N-source had no significant effect on total fresh weight per plant in the first season but urea application considerably depressed plant fresh weight as compared with ammonium nitrate in the second season.

Respecting with plant dry weight; leaves dry weight was increased significantly by ammonium nitrate application in the first season. Although the same trend was also detected in the second season, but variances failed to reach the level of significance. Dry weight of branches and total dry weight of plant foliage were significantly increased by ammonium nitrate application as compared with urea. The same trend was also detected in the first season but variances failed to be significant.

This favorable effect of ammonium nitrate fertilizer versus urea on plant growth was clear and significant in the second season and may be referred to the adverse effect of urea on tomato plant growth which could be referred to the high accumulation of $NH_4$-N in leaves of plants supplied with urea as a result of quick urea hydrolysis. These results are agree with Kooner and Rondhawa ( 1983 ); Magalhaes and Wilcox ( 1984 ) and Hartman et al ( 1986 ) working on tomato and Gabie ( 1983 ) on sweet pepper. It is worthy to mention that trails were done in a clay loam soil under field conditions i.e. clay loam soil contains enough organic matter to adsorb the $NH_4^+$ ions released

**Table (3): Vegetative growth of tomato plants, at fruit setting ( 70 days after transplanting, second sample ) as affected by source or level of nitrogen fertilizer, during the seasons of 1993 and 1994.**

**Early summer season, 1993**

| Treatments | Plant ht. Cm. | No. of leaves / plant | No. of branches / plant | Fresh weight ( g / plant ) | | | Dry weight ( g / plant ) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | leaves | branches | total | leaves | branches | total |
| **N-source** | | | | | | | | | |
| Urea | 48.38 | 43.09 | 5.23 | 76.14 | 43.86 | 120.00 | 14.44 | 6.52 | 20.96 |
| Amm. nitrate | 47.90 | 39.74 | 4.98 | 79.86 | 41.35 | 121.21 | 15.35 | 6.57 | 21.92 |
| **L.S.D. at 0.05** | **N.S.** | **3.06** | **N.S.** | **N.S.** | **2.38** | **N.S.** | **1.00** | **N.S.** | **N.S.** |
| **Kg N/fed.** | | | | | | | | | |
| 0 | 46.57 | 29.10 | 3.93 | 62.99 | 27.23 | 90.22 | 11.21 | 4.38 | 15.59 |
| 60 | 48.46 | 35.90 | 4.50 | 69.09 | 42.04 | 111.13 | 13.42 | 5.90 | 19.32 |
| 120 | 51.63 | 43.50 | 5.75 | 84.39 | 46.93 | 131.32 | 15.08 | 6.76 | 21.84 |
| 180 | 48.50 | 49.71 | 5.50 | 87.30 | 56.76 | 144.06 | 17.06 | 8.36 | 25.42 |
| 240 | 47.80 | 45.25 | 5.55 | 87.84 | 45.06 | 132.90 | 17.11 | 7.18 | 24.29 |
| 300 | 45.91 | 45.05 | 5.43 | 76.40 | 37.61 | 114.01 | 15.52 | 6.71 | 22.23 |
| **L.S.D. at 0.05** | **N.S.** | **5.31** | **0.88** | **8.66** | **4.13** | **10.31** | **1.73** | **0.82** | **2.20** |

**Early summer season, 1994**

| Treatments | Plant ht. Cm. | No. of leaves / plant | No. of branches / plant | Fresh weight ( g / plant ) | | | Dry weight ( g / plant ) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | leaves | branches | total | leaves | branches | total |
| **N-source** | | | | | | | | | |
| Urea | 48.52 | 54.38 | 7.38 | 110.42 | 158.15 | 268.57 | 15.83 | 22.71 | 38.54 |
| Amm. nitrate | 50.41 | 50.44 | 7.16 | 109.01 | 182.90 | 291.91 | 16.05 | 26.00 | 42.05 |
| **L.S.D. at 0.05** | N.S. | **3.90** | **N.S.** | **N.S.** | **17.47** | **17.40** | **N.S.** | **2.33** | **2.16** |
| **Kg N/fed.** | | | | | | | | | |
| 0 | 47.83 | 45.33 | 6.66 | 102.96 | 120.25 | 223.21 | 14.00 | 16.95 | 30.95 |
| 60 | 50.16 | 54.16 | 7.33 | 111.60 | 167.59 | 279.19 | 15.24 | 23.78 | 39.02 |
| 120 | 53.93 | 54.83 | 6.75 | 113.11 | 204.33 | 317.44 | 17.62 | 29.56 | 47.18 |
| 180 | 48.23 | 56.00 | 7.91 | 114.80 | 213.25 | 328.05 | 18.43 | 30.59 | 49.02 |
| 240 | 48.16 | 53.00 | 7.83 | 108.86 | 161.27 | 270.13 | 15.30 | 22.98 | 38.28 |
| 300 | 48.50 | 51.16 | 7.16 | 106.96 | 156.44 | 263.40 | 14.98 | 22.28 | 37.27 |
| **L.S.D. at 0.05** | **4.60** | **6.77** | **N.S.** | **8.16** | **30.26** | **30.14** | **1.30** | **4.03** | **3.74** |

from urea hydrolysis and that may explain the insignificant variances between urea and ammonium nitrate application on plant growth especially in the first season.

### 4.1.1.5. Effect of level of nitrogen application an vegetative growth of tomato plant at fruit setting stage.

Data in Table ( 3 ) showed that tomato plant growth parameters were significantly differed by level of N-fertilizer except plant height in the first season and number of branches per plant in the second one which its variances failed to reach the level of significance. Plant height increased by increasing N-level from 0 up to 120 Kg N/fed., but higher levels of N-application decreased it, especially in the first season. Number of leaves per plant was increased by adding N-fertilizer within all studied levels as compared with the control in both seasons. The maximum increases in number of leaves was found by adding 180 Kg N/fed in the first season, but no significant variances in number of leaves was found due to levels of N-application i.e. 60 up to 300 Kg N/fed., as shown in the second season. Respecting with number of branches per plant, it was increased by increasing nitrogen fertilizer level up to 120 Kg N/fed. as shown in the first season but no significant differences were found due to increasing levels of N-fertilizer in the second one.

Generally, it was clear that plant growth was significantly encouraged by N-application and the maximum plant height and number of branches per plant were obtained at 120 Kg N/fed. whereas, the highest number of leaves was obtained at 180 Kg N/fed.

Concerning the fresh and dry weight of leaves, branches and total fresh weight per plant, data in Table ( 3 ) showed that N-application within all the studied levels significantly increased fresh and dry weights of leaves and / or branches than the control. The highest plant growth was obtained by adding

180 Kg N/fed. in the first season as compared with all studied N-levels. The same trend was also detected in the second season however, no significant differences in plant growth were detected between plants supplied with 120 or 180 Kg N/fed. Heavy application of N-fertilizer at 240 or 300 Kg N/fed. depressed plant growth as compared with the optimum rate ( 180 Kg N/fed ) of both seasons. This vital role of nitrogen on encouraging plant growth could be referred to its role on protein synthesis, amino acid, enzymes and chlorophyll formation which consequently affect cell division, number of leaves and branches per plant as well as dry matter accumulation. Moreover, the depressive effect of heavy N-application on plant growth may be referred to the effect of heavy nitrogen fertilizer on soil salinity and consequently its osmotic effect on plant cells and other nutrients uptake, i.e. the depressive effect of $NO_3$- on $HPO_4^{--}$ uptake as well as $NH_4^+$ on $K^+$, $Ca^{++}$ and $Mg^{++}$ uptake ( Kirkby & Mengel, 1967 and Pill & Lambeth, 1977 ). Many investigators mentioned this favorable role of nitrogen application on plant growth among them, Doss et al ( 1975 ) who found that the maximum plant height was obtained by adding 130 Kg N/ha. Kooner and Randhawa ( 1983 ) recommend 200 Kg N/ha. to get the maximum plant growth. Grela Larenzo et al ( 1988 ) recommended 160 Kg N/ha. and found that 240 Kg N/ha. depressed tomato plant growth. El-Aela ( 1988 ) recommended 160 Kg N/fed. to gave the maximum dry weight of leaves or stem of tomato, he maintained that heavy N-application ( 200 or 240 Kg N/fed .) decreased the plant growth.

### 4.1.1.6. Effect of N-source within N-level on vegetative growth of tomato plant at fruit setting stage.

Data in Table ( 4 ) showed that plant height, number of leaves or branches and fresh weight of leaves per plant were not significantly affected by urea or ammonium nitrate application within all studied levels in both seasons

**Table (4): Vegetative growth of tomato plants, 70 days after transplanting ( second sample ) as affected by N-source within N-level, during the seasons of 1993 and 1994.**

**Early summer season, 1993**

| Treatments | | Plant ht. | No. of leaves | No. of branches | Fresh weight ( g / plant ) | | | Dry weight ( g / plant ) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| N-source | Kg N/fed. | Cm. | / plant | / plant | leaves | branches | total | leaves | branches | total |
| Urea | 0 | 46.57 | 29.10 | 3.93 | 62.99 | 27.23 | 90.22 | 11.21 | 4.38 | 15.59 |
| | 60 | 48.50 | 38.03 | 4.83 | 73.62 | 41.99 | 115.61 | 14.97 | 6.05 | 21.02 |
| | 120 | 56.07 | 43.66 | 6.00 | 82.09 | 50.81 | 132.90 | 14.45 | 6.96 | 21.41 |
| | 180 | 51.93 | 53.43 | 5.50 | 83.28 | 66.55 | 149.83 | 15.69 | 9.38 | 25.07 |
| | 240 | 44.33 | 47.50 | 5.27 | 84.73 | 40.05 | 124.78 | 15.96 | 5.83 | 21.79 |
| | 300 | 42.93 | 46.83 | 5.87 | 70.16 | 36.57 | 106.73 | 14.37 | 6.51 | 20.88 |
| Amm. nitrate | 0 | 46.57 | 29.10 | 3.93 | 62.99 | 27.23 | 90.22 | 11.21 | 4.38 | 15.59 |
| | 60 | 48.43 | 33.76 | 4.17 | 64.56 | 42.10 | 106.66 | 11.85 | 5.75 | 17.60 |
| | 120 | 47.20 | 43.33 | 5.50 | 86.70 | 43.05 | 129.75 | 15.72 | 6.55 | 22.27 |
| | 180 | 45.67 | 46.00 | 5.50 | 91.33 | 46.98 | 138.31 | 18.43 | 7.34 | 25.77 |
| | 240 | 51.67 | 43.00 | 5.83 | 90.96 | 50.07 | 141.03 | 18.27 | 8.53 | 26.80 |
| | 300 | 48.90 | 43.27 | 5.00 | 82.66 | 38.66 | 121.32 | 16.67 | 6.91 | 23.58 |
| L.S.D. at 0.05 | | 8.14 | N.S. | N.S. | N.S. | 5.84 | 14.59 | 2.45 | 1.17 | 3.12 |

**Early summer season, 1994**

| Treatments | | Plant ht. | No. of leaves | No. of branches | Fresh weight ( g / plant ) | | | Dry weight ( g / plant ) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| N-source | Kg N/fed. | Cm. | / plant | / plant | leaves | branches | total | leaves | branches | total |
| Urea | 0 | 47.83 | 45.33 | 6.66 | 102.96 | 120.25 | 223.21 | 14.00 | 16.95 | 30.95 |
| | 60 | 48.00 | 57.00 | 7.33 | 112.12 | 143.34 | 255.46 | 14.76 | 20.69 | 35.45 |
| | 120 | 49.86 | 56.00 | 7.00 | 113.88 | 176.39 | 290.27 | 17.16 | 25.98 | 43.14 |
| | 180 | 47.13 | 58.66 | 8.00 | 115.28 | 181.92 | 297.20 | 18.03 | 26.54 | 44.57 |
| | 240 | 48.33 | 55.66 | 8.00 | 109.30 | 167.34 | 276.64 | 15.60 | 23.64 | 39.24 |
| | 300 | 50.00 | 53.66 | 7.33 | 108.98 | 159.66 | 268.64 | 15.46 | 22.48 | 37.94 |
| Amm. nitrate | 0 | 47.83 | 45.33 | 6.66 | 102.96 | 120.25 | 223.21 | 14.00 | 16.95 | 30.95 |
| | 60 | 52.33 | 51.33 | 7.33 | 111.07 | 191.85 | 302.92 | 15.73 | 26.88 | 42.61 |
| | 120 | 58.00 | 53.66 | 6.50 | 112.35 | 232.28 | 344.63 | 18.07 | 33.14 | 51.21 |
| | 180 | 49.33 | 53.33 | 7.83 | 114.32 | 244.58 | 358.90 | 18.84 | 34.64 | 53.48 |
| | 240 | 48.00 | 50.33 | 7.66 | 108.41 | 155.20 | 263.61 | 15.14 | 22.33 | 37.47 |
| | 300 | 47.00 | 48.66 | 7.00 | 104.95 | 153.23 | 258.18 | 14.50 | 22.07 | 36.57 |
| L.S.D. at 0.05 | | N.S. | N.S. | N.S. | N.S. | 42.79 | 42.63 | N.S. | 5.70 | 5.29 |

except a little effect on plant height in the first season. The highest plants were recorded with 120-180 Kg urea/fed. or 240 Kg ammonium nitrate/fed. with no significant difference between each other and the shortest plants were recorded with 300 Kg urea / fed.

Concerning the total fresh and dry weights per plant, data showed that plants supplied with 180 Kg nitrogen as urea or 180-240 Kg nitrogen as ammonium nitrate gave similar and higher total fresh and dry weight than that of the other studied treatments in the first season. Whereas, plants received 120 or 180 Kg nitrogen as ammonium nitrate/fed. gave the highest growth expressed as fresh and dry weight per plant, followed by those received 120 or 180 Kg nitrogen as urea/fed. as shown in the second season. This result could be referred to the high fresh weight of branches and foliage produced under these treatments. It was clear that accumulation of dry matter was higher in plants received ammonium nitrate as compared with that received urea-N. On the other hand, the lowest values of fresh and dry weight of leaves and / or branches were found in control plants followed with those received heavy N-rate at 300 Kg N/fed. as urea followed by those received 240 Kg N as urea or ammonium nitrate.

The depressive effect of heavy urea application on plant growth is expected as shown in the second season and therefore plants supplied with ammonium nitrate surpassed those supplied with urea especially at high levels at 180 or 240 Kg N/fed.. The quick hydrolysis of urea to $NH_4CO_3$ and consequently to $NH_4^+$ may be responsible for the adverse effect of urea application on tomato plant growth especially at the high N-levels i.e. 240 or 300 Kg N/fed.. This result agree with those of El-Aela ( 1988 ) working on tomato supplied with urea at 40, 80, 120, 160, 200 and 240 Kg N/fed. and Gabal ( 1983 ) working on sweet peppers supplied with 300 ppm urea-N.

On the other hand, the adverse effect of urea versus ammonium nitrate on plant growth was less detected in the first season up to 180 Kg N/fed.. This result may be refereed to that the tomato here were grown in a clay loam soil which contained enough dry matter to absorb the $NH_4$+ released from urea hydrolysis. Moreover, the ammonium nitrate fertilizer contains 16.5 % N-$NH_4$. This result agree with El -Aela ( 1988 ) working on tomato grown on clayloam soil supply with urea .

## 4.1.2. Mineral content of tomato plant foliage:

### 4.1.2.1. Effect of nitrogen source on mineral content of tomato plant foliage at flowering stage.

Data on $NO_3$-N, N, P and K % and its uptake of tomato plant leaves or stem as affected by N-source are given in Table ( 5 ). Results showed that N % and $NO_3$-N % were higher in leaves and branches of plants supplied with ammonium nitrate as compared with those received urea, as shown in both seasons. This result was also true for total-N % in branches and stem except in the first season as shown in Table ( 7 ).

Concerning N-uptake data in Table ( 6 ) showed the same trend especially for N-uptake in branches and whole plant foliage in the second season only, when plants supplied with ammonium nitrate accumulated higher total-N ( mg/plant ) as compared with that of urea. These results reflex the superiority of ammonium nitrate versus urea in tomato nutrition especially ammonium nitrate contains $NH_4$: $NO_3$ (1:1) so that ammonium nitrate gave a higher content of N in plant organs. Added to that urea should be converted to ammonium by ureases enzyme before its uptake. These results are completely agree with Kirkby and Mengel ( 1967 ), Blair et al ( 1970 ), De Classen and Wilcox ( 1974 ). Polizotta et al ( 1975 ), they reporting that tomato plants

**Table (5): NO3-N, N, P and K % of tomato plant foliage at flowering stage as affected by N-source or N-level, during the seasons of 1993 and 1994.**

**Early summer season, 1993**

| Treatments | Leaves | | | | Branches | | | |
|---|---|---|---|---|---|---|---|---|
| | NO3-N % | N% | P % | K % | NO3-N % | N % | P % | K % |
| **N-source** | | | | | | | | |
| Urea | 0.284 | 4.61 | 0.40 | 3.88 | 0.399 | 3.77 | 0.30 | 3.50 |
| Amm. nitrate | 0.397 | 5.11 | 0.39 | 4.27 | 0.492 | 4.00 | 0.15 | 3.66 |
| **L.S.D. at 0.05** | **0.023** | **0.31** | **N.S.** | **0.33** | **0.025** | **N.S.** | **0.02** | **N.S.** |
| **Kg N/fed.** | | | | | | | | |
| 0 | 0.12 | 3.50 | 0.33 | 3.16 | 0.19 | 2.83 | 0.26 | 3.00 |
| 60 | 0.15 | 4.66 | 0.42 | 3.91 | 0.28 | 3.83 | 0.31 | 3.58 |
| 120 | 0.26 | 5.16 | 0.42 | 4.16 | 0.35 | 3.91 | 0.32 | 3.58 |
| 180 | 0.43 | 5.58 | 0.40 | 4.33 | 0.52 | 4.58 | 0.32 | 3.66 |
| 240 | 0.49 | 5.50 | 0.41 | 4.41 | 0.60 | 4.50 | 0.32 | 3.91 |
| 300 | 0.59 | 4.75 | 0.41 | 4.50 | 0.73 | 3.66 | 0.32 | 3.75 |
| **L.S.D. at 0.05** | **0.04** | **0.53** | **0.05** | **0.58** | **0.04** | **0.64** | **0.03** | **0.53** |

**Early summer season, 1994**

| Treatments | Leaves | | | | Branches | | | |
|---|---|---|---|---|---|---|---|---|
| | NO3-N % | N% | P % | K % | NO3-N % | N % | P % | K % |
| **N-source** | | | | | | | | |
| Urea | 0.275 | 4.94 | 0.39 | 4.02 | 0.312 | 3.94 | 0.29 | 3.72 |
| Amm. nitrate | 0.312 | 5.38 | 0.39 | 4.16 | 0.380 | 4.33 | 0.29 | 3.97 |
| **L.S.D. at 0.05** | **0.026** | **0.24** | **N.S.** | **N.S.** | **0.023** | **0.31** | **N.S.** | **N.S.** |
| **Kg N/fed.** | | | | | | | | |
| 0 | 0.09 | 3.83 | 0.32 | 3.33 | 0.16 | 3.00 | 0.23 | 3.33 |
| 60 | 0.11 | 5.00 | 0.39 | 3.91 | 0.19 | 4.00 | 0.30 | 3.91 |
| 120 | 0.24 | 5.58 | 0.42 | 4.25 | 0.25 | 4.25 | 0.32 | 4.25 |
| 180 | 0.31 | 5.83 | 0.41 | 4.41 | 0.37 | 4.83 | 0.31 | 4.41 |
| 240 | 0.43 | 5.75 | 0.41 | 4.33 | 0.49 | 4.58 | 0.30 | 4.33 |
| 300 | 0.57 | 5.00 | 0.40 | 4.33 | 0.62 | 4.16 | 0.31 | 4.33 |
| **L.S.D. at 0.05** | **0.04** | **0.42** | **0.02** | **0.40** | **0.04** | **0.54** | **0.03** | **0.41** |

**Table (6): NO3-N, N, P and K uptake of tomato plant foliage at flowering stage as affected by N-source or N-level, during the seasons of 1993 and 1994.**

**Early summer season, 1993**

| Treatments | Leaves ( mg/plant ) | | | Branches ( mg/plant ) | | | Total foliage ( mg/plant ) | | |
|---|---|---|---|---|---|---|---|---|---|
| | N | P | K | N | P | K | N | P | K |
| **N-source** | | | | | | | | | |
| Urea | 164.60 | 14.00 | 133.50 | 68.40 | 5.10 | 60.90 | 233.00 | 19.10 | 194.40 |
| Amm. nitrate | 165.50 | 12.70 | 136.90 | 63.20 | 5.00 | 56.90 | 228.70 | 17.70 | 193.80 |
| **L.S.D. at 0.05** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** |
| **Kg N/fed.** | | | | | | | | | |
| 0 | 105.00 | 9.70 | 93.50 | 38.50 | 3.50 | 39.80 | 143.50 | 13.20 | 133.30 |
| 60 | 156.00 | 13.80 | 129.30 | 64.60 | 4.60 | 53.10 | 220.60 | 18.40 | 182.40 |
| 120 | 187.00 | 15.10 | 149.00 | 67.50 | 5.60 | 61.40 | 254.50 | 20.70 | 210.40 |
| 180 | 215.30 | 15.40 | 166.90 | 89.10 | 6.30 | 72.30 | 304.40 | 21.70 | 239.20 |
| 240 | 179.70 | 13.40 | 143.60 | 74.20 | 5.20 | 64.40 | 253.90 | 18.60 | 208.00 |
| 300 | 147.10 | 12.50 | 135.70 | 60.80 | 5.20 | 62.40 | 207.90 | 17.70 | 198.10 |
| **L.S.D. at 0.05** | **44.63** | **3.68** | **30.10** | **17.50** | **1.00** | **14.50** | **50.60** | **4.50** | **40.40** |

**Early summer season, 1994**

| Treatments | Leaves ( mg/plant ) | | | Branches ( mg/plant ) | | | Total foliage ( mg/plant ) | | |
|---|---|---|---|---|---|---|---|---|---|
| | N | P | K | N | P | K | N | P | K |
| **N-source** | | | | | | | | | |
| Urea | 551.50 | 44.00 | 447.20 | 170.30 | 12.80 | 159.90 | 721.80 | 56.80 | 607.10 |
| Amm. nitrate | 586.20 | 42.70 | 452.60 | 206.70 | 13.90 | 187.20 | 792.90 | 56.60 | 639.80 |
| **L.S.D. at 0.05** | **N.S.** | **N.S.** | **N.S.** | **28.70** | **N.S.** | **25.30** | **58.10** | **N.S.** | **N.S.** |
| **Kg N/fed.** | | | | | | | | | |
| 0 | 322.40 | 26.90 | 275.80 | 97.90 | 7.40 | 108.50 | 420.30 | 34.30 | 384.30 |
| 60 | 506.90 | 40.30 | 395.00 | 172.40 | 12.90 | 162.10 | 679.30 | 43.20 | 557.10 |
| 120 | 660.80 | 50.40 | 505.60 | 215.90 | 16.30 | 201.70 | 876.70 | 66.70 | 707.30 |
| 180 | 767.30 | 54.00 | 585.10 | 264.70 | 16.80 | 222.70 | 1032.00 | 70.80 | 807.80 |
| 240 | 613.00 | 44.60 | 465.10 | 196.40 | 12.90 | 174.70 | 809.40 | 57.50 | 639.80 |
| 300 | 542.70 | 44.00 | 473.00 | 183.80 | 13.80 | 171.60 | 726.50 | 57.80 | 644.60 |
| **L.S.D. at 0.05** | **109.60** | **8.20** | **98.50** | **49.60** | **3.00** | **43.70** | **100.60** | **9.50** | **108.50** |

fertilized with urea-N had a lower N-content in leaves and stem than in plants fertilized with $NO_3$ or $NH_4$-N sources.

Concerning the stimulating effect of ammonium nitrate fertilizer on $NO_3$-N % in plant leaves and stems as compared with urea, results are in agreement with Pill and Lambeth ( 1977 ); Kanozirska and Boboshevska (1981), Gabal ( 1983 ) and Ikeda and Osawa ( 1983 ). They reported that $NO_3$-N nutrition resulted in higher nitrate accumulation as compared with $NH_4$-N nutrition.

On the other hand, data in Table ( 6 ) showed that total-N uptake of leaves in both seasons and total-N uptake of branches or whole plant in the first season did not show any significant differences between urea and ammonium nitrate. This result may be due to the insignificant differences in dry weights of leaves and total plant foliage of tomato plants supplied with urea or ammonium nitrate at this time of sampling ( flowering stage ). This result reflect the slight superiority of ammonium nitrate on tomato growth and consequently total-N and $NO_3$-N % in leaves. The adverse effect of urea applications was not clear because tomato plant of this experiment were grown in a clay loam i.e. this soil contains enough organic matter content to adsorb the release $NH_4^+$ after urea hydrolysis and therefore the adverse effect of urea application was less pronounced. The superiority of ammonium nitrate versus urea more clear in sandy soil poor in organic matter and less pronounced in clay loam soil ( Gabal, 1983 ), Magalhaes and Wilcox ( 1984 ) also found that tomato plant growth was much better with $NO_3$-N than with $NH_4$-N in sandy soil.

Concerning with phosphorus content of plant organs. data in Table ( 5 & 6 ) showed that N-source had no significant effect on P % and P-uptake in leaves, branches and total plant foliage in both seasons with except in the first season, whereas urea application had increased P-content in branches as compared with ammonium nitrate. This result may be due to that urea is converted to $NH_4^+$ after hydrolysis and $NH_4^+$ cations may stimulate the uptake of $HPO_4^{--}$ ions. This result agrees with theory of cation-anino balance in plant tissues mentioned by Kirkby and Mengel ( 1967 ).

With respect to potassium content data in Table ( 5 & 6 ) showed that there were no significant effect of urea or ammonium nitrate on K % or K-uptake except for K % in leaves in the first season and K-uptake of branches in the second season. These results agree with Pill and Lambeth (1977). They reported that fertilization with $NH_4$-N reduced leaf, shoot and root concentration of Ca, Mg, K, P and $NO_3$-N and also is in harmony with cation-anion balance theory of Kirkby and Mengel ( 1967 ).

### 4.1.2.2. Effect of level of N-application on mineral content of tomato plant foliage at flowering stage.

Data in Table ( 5 ) showed that increasing level of N-application from 0, 60 up to 120 Kg N/fed. gradually increased N % in leaves. However adding higher levels of N-fertilizer i.e. 180 and 240 Kg N/fed. did not increase it. Moreover, heavy N-application at 300 Kg N/fed. significantly decreased N % in leaves. These results were true in both seasons. Whereas, N % in branches showed the same response which significantly increased by increasing level of N-application from 0 up to 180 Kg N/fed. with no significant difference between 180 and 240 Kg N/fed. and then decreased with adding heavy N-application as 300 Kg N/fed. in both seasons.

Results of N-uptake ( Table, 6 ) showed that increasing level of N-fertilizer significantly increased N-uptake of leaves, branches and total plant foliage reached to the maximum N-uptake at 120 or 180 Kg N/fed. for each, respectively as a general trend of both seasons. Higher levels of N-application did not increase N-uptake, however the heavy levels of 300 Kg N/fed. in the first season and 240 or 300 Kg N/fed. in the second one decreased N-uptake of leaves, branches and total plant foliage.
These results agree with those of Hargitai and Vass ( 1976 ); Kanazirska and Boboshevska ( 1981 ). Moreover, Gabal et al ( 1990 ) reported that urea application up to 120 Kg N/fed. significantly increased N % and uptake of leaves however, urea application at 240 Kg N/fed. decrease it .

Concerning with $NO_3$-N content in leaves and branches, data in Table ( 5 ) showed that increasing level of N-fertilizer gradually and significantly increased $NO_3$-N concentration in leaves and branches in both seasons. Obtained results may be due to increase in N-uptake which increased $NO_3$-N % by increasing level of N-application. This result agrees with Minotti ( 1975 ); Pill et al ( 1978 ); Ikeda and Osawa ( 1983 ) and Magalhaes and Wilcox ( 1984 ). They reported that nitrate accumulation in plant tissues is mainly increased by increasing the level of $NO_3$-N in the soil. Kanazirsaka and Boboshevska ( 1981 ) also found high positive correlation between soil-N and leaf $NO_3$-N content.

Concerning P-content, results ( Tables 5 & 6 ) showed that P % in leaves or branches increased gradually and significantly by increasing level of N-application from 0, 60 or 120 Kg N/fed. but higher levels of N-application ( 180, 240 and 300 Kg N/fed. ) did not increase P % in plant organs and sometimes decreased it as a general trend in both season. P-uptake of leaves and / or branches also showed the same trend i.e. P-uptake was increased by increasing level of N-application from 0, 60 or 120 Kg N/fed. and then decreased by heavy N-application at 240 or 300 Kg N/fed., especially in the second season.

Concerning K-content of leaves or branches data in Tables (5 & 6) showed that K % and K-uptake in leaves and branches gradually and significantly increased by increasing level of N-application from 0 up to 120 Kg N/fed. with no significant differences between K % in leaves and branches at 120 up to 300 Kg N/fed. in both seasons. Data in Table ( 6 ) also showed that K-uptake of leaves and / or branches were depressed in plants received 240 or 300 Kg N/fed. The stimulating effect of N-application with moderate level on K-uptake should be refereed to the encourage role of nitrogen application on plant growth which increased dry weight and the uptake of other nutrients including potassium.

### 4.1.2.3. Effect of N-source within N-level on mineral content of tomato plant foliage at flowering stage.

Data in Tables ( 7 & 8 ) showed that nitrogen source within levels had no significant effect on N, P and K % or its uptake in leaves and branches in both seasons except for N % in leaves in the second season when plants fertilized with ammonium nitrate at 120 Kg N/fed. had higher N % in leaves as compared with the lower N-levels either from urea or ammonium nitrate. Moreover, increasing levels of ammonium nitrate application at 120, 180, 240 and 300 Kg N/fed. did not led to any considerable increase in leaf N % . The lowest value of N % was recorded in the control when no nitrogen was added.

**Table (7): NO3-N, N, P and K concentration of tomato plant foliage at flowering stage as affected by N-source within N-level, during the early summer seasons of 1993 and 1994.**

**Early summer season, 1993**

| Treatments | | Leaves | | | | Branches | | | |
|---|---|---|---|---|---|---|---|---|---|
| N-source | Kg N/fed. | NO3-N % | N% | P% | K% | NO3-N % | N % | P % | K % |
| Urea | 0 | 0.119 | 3.50 | 0.33 | 3.16 | 0.190 | 2.83 | 0.26 | 3.00 |
| | 60 | 0.151 | 4.83 | 0.44 | 3.50 | 0.246 | 3.83 | 0.31 | 3.50 |
| | 120 | 0.214 | 4.83 | 0.43 | 3.83 | 0.294 | 3.66 | 0.32 | 3.33 |
| | 180 | 0.357 | 5.33 | 0.40 | 4.16 | 0.484 | 4.33 | 0.32 | 3.66 |
| | 240 | 0.403 | 5.00 | 0.40 | 4.16 | 0.539 | 4.50 | 0.29 | 3.83 |
| | 300 | 0.460 | 4.16 | 0.41 | 4.50 | 0.643 | 3.50 | 0.30 | 3.66 |
| Amm. nitrate | 0 | 0.119 | 3.50 | 0.33 | 3.16 | 0.190 | 2.83 | 0.26 | 3.00 |
| | 60 | 0.159 | 4.50 | 0.41 | 4.33 | 0.317 | 3.83 | 0.32 | 3.66 |
| | 120 | 0.298 | 5.50 | 0.41 | 4.50 | 0.405 | 4.16 | 0.33 | 3.83 |
| | 180 | 0.508 | 5.83 | 0.40 | 4.50 | 0.555 | 4.83 | 0.32 | 3.66 |
| | 240 | 0.587 | 6.00 | 0.42 | 4.66 | 0.666 | 4.50 | 0.35 | 4.00 |
| | 300 | 0.714 | 5.33 | 0.41 | 4.50 | 0.817 | 3.83 | 0.35 | 3.83 |
| **L.S.D. at 0.05** | | **0.056** | **N.S.** | **N.S.** | **N.S.** | **0.061** | **N.S.** | **N.S.** | **N.S.** |

**Early summer season, 1994**

| Treatments | | Leaves | | | | Branches | | | |
|---|---|---|---|---|---|---|---|---|---|
| N-source | Kg N/fed. | NO3-N % | N% | P% | K% | NO3-N % | N % | P % | K % |
| Urea | 0 | 0.095 | 3.83 | 0.32 | 3.33 | 0.156 | 3.00 | 0.23 | 3.33 |
| | 60 | 0.111 | 5.16 | 0.40 | 3.83 | 0.173 | 4.00 | 0.30 | 3.66 |
| | 120 | 0.222 | 5.33 | 0.43 | 4.16 | 0.238 | 4.00 | 0.31 | 3.66 |
| | 180 | 0.291 | 5.33 | 0.39 | 4.33 | 0.312 | 4.50 | 0.31 | 3.83 |
| | 240 | 0.397 | 5.33 | 0.42 | 4.16 | 0.426 | 4.33 | 0.31 | 4.00 |
| | 300 | 0.532 | 4.33 | 0.41 | 4.33 | 0.564 | 3.83 | 0.31 | 3.83 |
| Amm. nitrate | 0 | 0.095 | 3.83 | 0.32 | 3.33 | 0.156 | 3.00 | 0.23 | 3.33 |
| | 60 | 0.115 | 4.83 | 0.39 | 4.00 | 0.199 | 4.00 | 0.30 | 3.83 |
| | 120 | 0.254 | 5.83 | 0.42 | 4.33 | 0.265 | 4.50 | 0.32 | 4.16 |
| | 180 | 0.327 | 6.00 | 0.42 | 4.50 | 0.435 | 5.16 | 0.30 | 4.33 |
| | 240 | 0.469 | 6.16 | 0.41 | 4.50 | 0.554 | 4.83 | 0.30 | 4.16 |
| | 300 | 0.615 | 5.66 | 0.39 | 4.33 | 0.672 | 4.50 | 0.31 | 4.00 |
| **L.S.D. at 0.05** | | **N.S.** | **0.60** | **N.S.** | **N.S.** | **0.057** | **N.S.** | **N.S.** | **N.S.** |

**Table (8): N, P and K uptake of tomato plant foliage at flowering stage as affected by N-source within N-level, during the summer seasons of 1993 and 1994.**

**Early summer season, 1993**

| Treatments | | Leaves ( mg/plant ) | | | Branches ( mg/plant ) | | | Total foliage ( mg/plant ) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| N-source | Kg N/fed. | N | P | K | N | P | K | N | P | K |
| Urea | 0 | 105.00 | 9.70 | 93.50 | 115.70 | 3.50 | 39.80 | 220.70 | 13.20 | 133.30 |
| | 60 | 180.80 | 15.60 | 132.40 | 229.20 | 4.90 | 56.10 | 410.00 | 20.50 | 188.50 |
| | 120 | 181.80 | 16.10 | 144.00 | 200.00 | 5.80 | 60.70 | 381.80 | 21.90 | 204.70 |
| | 180 | 224.20 | 16.90 | 175.10 | 282.00 | 7.10 | 80.90 | 506.20 | 24.00 | 256.00 |
| | 240 | 169.60 | 13.40 | 138.80 | 227.50 | 4.80 | 64.20 | 397.10 | 18.20 | 203.00 |
| | 300 | 126.20 | 12.30 | 131.00 | 177.00 | 4.90 | 63.50 | 303.20 | 17.20 | 194.50 |
| Amm. nitrate | 0 | 105.00 | 9.70 | 93.50 | 115.70 | 3.50 | 39.80 | 220.70 | 13.20 | 133.30 |
| | 60 | 131.20 | 12.10 | 126.20 | 158.50 | 4.40 | 50.10 | 289.70 | 16.50 | 176.30 |
| | 120 | 192.30 | 14.20 | 154.10 | 205.50 | 5.40 | 62.10 | 397.80 | 19.60 | 216.20 |
| | 180 | 206.40 | 14.00 | 158.80 | 252.90 | 5.50 | 63.80 | 459.30 | 19.50 | 222.60 |
| | 240 | 189.80 | 13.30 | 148.40 | 218.10 | 5.70 | 64.60 | 407.90 | 19.00 | 213.00 |
| | 300 | 168.10 | 12.80 | 140.40 | 187.80 | 5.60 | 61.20 | 355.90 | 18.40 | 201.60 |
| **L.S.D. at 0.05** | | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** |

**Early summer season, 1994**

| Treatments | | Leaves ( mg/plant ) | | | Branches ( mg/plant ) | | | Total foliage ( mg/plant ) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| N-source | Kg N/fed. | N | P | K | N | P | K | N | P | K |
| Urea | 0 | 322.40 | 26.90 | 275.80 | 97.90 | 7.40 | 108.50 | 420.30 | 34.30 | 384.30 |
| | 60 | 508.60 | 39.50 | 376.60 | 153.20 | 11.50 | 140.60 | 661.80 | 51.00 | 517.20 |
| | 120 | 636.90 | 51.40 | 497.10 | 190.50 | 15.20 | 177.50 | 827.40 | 66.60 | 674.60 |
| | 180 | 748.20 | 52.40 | 575.80 | 228.90 | 15.70 | 193.90 | 977.10 | 68.10 | 769.70 |
| | 240 | 589.70 | 46.20 | 457.90 | 178.10 | 12.70 | 165.80 | 767.80 | 58.90 | 623.70 |
| | 300 | 503.10 | 47.50 | 500.30 | 173.40 | 14.30 | 173.40 | 676.50 | 61.80 | 673.70 |
| Amm. nitrate | 0 | 322.40 | 26.90 | 275.80 | 97.90 | 7.40 | 108.50 | 420.30 | 34.30 | 384.30 |
| | 60 | 505.20 | 41.00 | 413.40 | 191.60 | 14.30 | 183.60 | 696.80 | 55.30 | 597.00 |
| | 120 | 684.80 | 49.50 | 514.10 | 241.20 | 17.40 | 226.00 | 926.00 | 66.90 | 740.10 |
| | 180 | 786.30 | 55.60 | 594.50 | 300.40 | 17.90 | 251.50 | 1086.70 | 73.50 | 846.00 |
| | 240 | 636.30 | 42.90 | 472.40 | 214.80 | 13.10 | 183.50 | 851.10 | 56.00 | 655.90 |
| | 300 | 582.40 | 40.50 | 445.70 | 194.20 | 13.40 | 169.80 | 776.60 | 53.90 | 615.50 |
| **L.S.D. at 0.05** | | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** |

Concerning $NO_3$-N content of leaves and branches, data showed that incresining levels of N-fertilizer either as urea or ammonium nitrate significantly increased $NO_3$-N content of leaves and branches. This trend was true in both seasons except for $NO_3$-N of leaves in the second one when variances failed to reach the level of significance. Data also clearly showed that $NO_3$-N concentration in leaves and branches were higher in plants received ammonium nitrate as compared with those received urea especially at the high levels 120, 180, 240 or 300 Kg N/Fed.. Therefore, the highest accumulation of $NO_3$-N was found in plants received the highest N-dose i.e. 300 Kg N/Fed. These results were agree with Minotti ( 1975 ); Pill et al ( 1978 ), Ikeda and Osawa ( 1983 ) and Manalhaes and Wilcox ( 1984 ). Kanazirska and Boboshevska ( 1981 ) found a high positive correlation between soil-N and leaf $NO_3$-N content. Pill and Lambeth ( 1977 ) found that $NH_4$-N application reduced $NO_3$-N content of shoots and roots as compared with plants cultured with $NO_3$-N.

Concerning P and K percentage and uptake, Tables ( 7 and 8 ) showed that they were not significantly differed due to forms within levels of N-fertilizer in both seasons. This result indicate that P and K content of tomato plant leaves and branches were mainly differed due to the levels of N-fertilizer used in tomato nutrition. Whereas, N-level within N-forms had no significant effect on P and K content of plant foliage. This result may be referred to that tomato plants were grown in a clayloam soil and received a standard levels of P and K fertilizers i.e. 64 Kg $P_2O_5$/fed. and 48 Kg $K_2O$/fed. for all experimental plots of this experiment.

### 4.1.2.4. Effect of N-source on $NO_3$-N, total-N, P and K contents of tomato plant foliage at fruit setting stage.

Concerning the plant analysis of the second sample data in Tables ( 9 & 10 ) indicated that total-N % and uptake ( mg/plant ) were significantly increased in leaves and foliage of tomato plants fertilized with ammonium nitrate as compared with that received urea, as shown in both seasons. results of $NO_3$-N %, N-uptake of branches also showed the same trend i.e. they were increased by ammonium nitrate application more than by urea. This result may be due to that 50 % of the ammonium nitrate fertilizer is $NO_3$-N and agree with Polizatta et al ( 1975 ) and Pill and Lambeth ( 1977 ). They mentioned that $NO_3$-N accumulation in plant organs were increased by increasing $NO_3$-N in plant media or soil. Data also showed that total-N % of branches of both seasons and uptake of branches in the first one were not significantly differed due to the source of N-fertilizer. This result may be referred to the translocation of nitrogen from branches to flowers at fruit setting stage.

Phosphorus content in leaves or branches ( Tables, 9 & 10 ) were not considerably affected by source of N-application in both seasons except P-uptake in leaves and total plant foliage were increased significantly by ammonium nitrate application as compared with urea application in the first season. This result may be referred to the encourage effect of ammonium nitrate fertilizer on tomato plant fresh and dry weights as compared with urea.

**Table (9): NO3-N, N, P and K % and uptake of tomato plant foliage, 70 days after transplanting ( second sample ) as affected by N-source or N-level, during the seasons of 1993 and 1994.**

**Element % at early summer season, 1993**

| Treatments | Leaves | | | | Branches | | | |
|---|---|---|---|---|---|---|---|---|
| | NO3-N % | N% | P% | K% | NO3-N % | N % | P % | K % |
| **N-source** | | | | | | | | |
| Urea | 0.173 | 4.11 | 0.33 | 4.69 | 0.219 | 3.69 | 0.24 | 4.05 |
| Amm. nitrate | 0.208 | 4.66 | 0.34 | 5.13 | 0.250 | 3.75 | 0.25 | 4.16 |
| **L.S.D. at 0.05** | **0.013** | **0.44** | **N.S.** | **0.33** | **0.013** | **N.S.** | **N.S.** | **N.S.** |
| **Kg/fed.** | | | | | | | | |
| 0 | 0.09 | 3.50 | 0.31 | 3.83 | 0.11 | 3.33 | 0.21 | 3.50 |
| 60 | 0.10 | 4.08 | 0.34 | 4.66 | 0.15 | 3.66 | 0.25 | 4.08 |
| 120 | 0.15 | 4.58 | 0.34 | 4.75 | 0.20 | 3.91 | 0.27 | 4.25 |
| 180 | 0.21 | 4.83 | 0.35 | 5.50 | 0.25 | 3.91 | 0.26 | 4.50 |
| 240 | 0.29 | 4.91 | 0.36 | 5.41 | 0.33 | 3.91 | 0.24 | 4.25 |
| 300 | 0.31 | 4.41 | 0.34 | 5.33 | 0.36 | 3.58 | 0.26 | 4.08 |
| **L.S.D. at 0.05** | **0.02** | **0.76** | **N.S.** | **0.57** | **0.02** | **N.S.** | **0.02** | **N.S.** |

**Element % at early summer season, 1994**

| Treatments | Leaves | | | | Branches | | | |
|---|---|---|---|---|---|---|---|---|
| | NO3-N % | N% | P% | K% | NO3-N % | N % | P % | K % |
| **N-source** | | | | | | | | |
| Urea | 0.247 | 4.08 | 0.32 | 4.41 | 0.281 | 3.88 | 0.26 | 4.11 |
| Amm. nitrate | 0.293 | 4.75 | 0.32 | 4.58 | 0.330 | 3.97 | 0.26 | 4.22 |
| **L.S.D. at 0.05** | **0.017** | **0.28** | **N.S.** | **N.S.** | **0.017** | **N.S.** | **N.S.** | **N.S.** |
| **Kg/fed.** | | | | | | | | |
| 0 | 0.08 | 3.16 | 0.30 | 3.66 | 0.10 | 3.50 | 0.25 | 3.16 |
| 60 | 0.10 | 4.08 | 0.33 | 4.33 | 0.16 | 3.83 | 0.27 | 4.08 |
| 120 | 0.22 | 4.66 | 0.33 | 4.66 | 0.24 | 4.08 | 0.28 | 4.50 |
| 180 | 0.30 | 4.75 | 0.34 | 4.83 | 0.33 | 4.25 | 0.26 | 4.83 |
| 240 | 0.40 | 5.25 | 0.32 | 4.83 | 0.44 | 4.08 | 0.26 | 4.33 |
| 300 | 0.53 | 4.58 | 0.32 | 4.66 | 0.57 | 3.83 | 0.25 | 4.08 |
| **L.S.D. at 0.05** | **0.03** | **0.59** | **N.S.** | **0.54** | **0.03** | **N.S.** | **N.S.** | **0.38** |

**Table (10): N, P and K uptake of tomato plant foliage, 70 days after transplanting ( second sample ) as affected by N-source or N-level, during the early summer seasons of 1993 and 1994.**

**Element uptake at early summer season, 1993**

| Treatments | Leaves ( mg/plant ) | | | Branches ( mg/plant ) | | | Total foliage ( mg/plant ) | | |
|---|---|---|---|---|---|---|---|---|---|
| | N | P | K | N | P | K | N | P | K |
| **N-source** | | | | | | | | | |
| Urea | 608.90 | 48.80 | 686.70 | 241.00 | 16.30 | 268.70 | 849.90 | 65.10 | 955.40 |
| Amm. nitrate | 730.00 | 57.20 | 806.70 | 248.20 | 16.80 | 278.00 | 978.20 | 74.00 | 1084.70 |
| **L.S.D. at 0.05** | **78.58** | **7.91** | **79.54** | **N.S.** | **N.S.** | **N.S.** | **90.86** | **8.70** | **89.63** |
| **Kg/fed.** | | | | | | | | | |
| 0 | 391.60 | 34.60 | 430.20 | 145.40 | 9.10 | 154.60 | 537.00 | 43.70 | 584.80 |
| 60 | 541.50 | 56.70 | 624.40 | 214.30 | 14.70 | 240.90 | 755.80 | 71.40 | 865.30 |
| 120 | 695.00 | 52.50 | 717.80 | 263.90 | 18.30 | 285.40 | 958.90 | 70.80 | 1003.20 |
| 180 | 827.10 | 59.50 | 943.60 | 325.20 | 21.90 | 375.80 | 1152.30 | 81.40 | 1319.40 |
| 240 | 845.20 | 61.70 | 931.50 | 279.90 | 17.50 | 307.30 | 1125.10 | 79.20 | 1238.80 |
| 300 | 716.50 | 53.00 | 832.80 | 239.10 | 18.00 | 276.10 | 955.60 | 71.00 | 1108.90 |
| **L.S.D. at 0.05** | **136.10** | **13.71** | **137.77** | **50.59** | **2.03** | **62.76** | **157.38** | **15.08** | **155.25** |

**Element uptake at early summer season,1994**

| Treatments | Leaves ( mg/plant ) | | | Branches ( mg/plant ) | | | Total foliage ( mg/plant ) | | |
|---|---|---|---|---|---|---|---|---|---|
| | N | P | K | N | P | K | N | P | K |
| **N-source** | | | | | | | | | |
| Urea | 649.90 | 51.70 | 701.20 | 891.60 | 61.40 | 953.00 | 1541.50 | 113.10 | 1654.20 |
| Amm. nitrate | 770.70 | 52.60 | 741.60 | 1056.10 | 68.20 | 1130.50 | 1826.80 | 120.80 | 1872.10 |
| **L.S.D. at 0.05** | **50.33** | **N.S.** | **N.S.** | **132.39** | **N.S.** | **124.85** | **139.19** | **N.S.** | **122.81** |
| **Kg/fed.** | | | | | | | | | |
| 0 | 443.90 | 42.40 | 511.60 | 601.80 | 42.00 | 541.80 | 1045.70 | 84.40 | 1053.40 |
| 60 | 624.80 | 50.50 | 660.90 | 919.90 | 64.70 | 977.90 | 1544.70 | 115.20 | 1638.80 |
| 120 | 825.00 | 59.10 | 821.60 | 1222.60 | 82.40 | 1335.20 | 2047.60 | 141.50 | 2156.80 |
| 180 | 876.80 | 63.00 | 890.60 | 1308.10 | 81.60 | 1478.80 | 2184.90 | 144.60 | 2369.40 |
| 240 | 805.00 | 49.50 | 744.90 | 930.80 | 61.20 | 999.30 | 1735.80 | 110.70 | 1744.20 |
| 300 | 686.60 | 48.40 | 699.10 | 859.80 | 56.90 | 917.40 | 1546.40 | 105.30 | 1616.50 |
| **L.S.D. at O.O5** | **87.18** | **6.98** | **102.41** | **229.30** | **14.16** | **216.26** | **241.08** | **15.51** | **212.71** |

K % and K-uptake in leaves increased significantly by ammonium nitrate application as compared with urea fertilizer in the first season.K-uptake of whole plant foliage also showed the same trend in both seasons. K-uptake of branches also support the same trend but variances were only significant in the second season. The enhancing effect of ammonium nitrate versus urea on K-uptake may be refereed to the stimulating effect of $NO_3^-$ on $K^+$ uptake according to the theory of cation-anion balance in plant tissues mentioned by Kirkby and Mangel ( 1967 ). These results also agrees with De Classen and Wilcox ( 1974 ), Polizatta et al ( 1975 ) and Pill and Lambeth ( 1977 ). They reported that fertilization with $NH_4$-N reduced Ca, Mg, K, P and $NO_3$-N % of leaves and branches as compared with $NO_3$-N fertilization.

### 4.1.2.5. Effect of level of N-application on $NO_3$-N, total -N, P and K contents of tomato plant foliage at fruit setting stage.

Data in Tables ( 9) showed that increasing N-application from 0 up to 120 Kg N/fed. gradually increased N % in leaves, however higher levels of N-application; 180, 240 and 300 Kg N/fed. did not significantly increase N % of leaves and 300 Kg N/fed. seemed to decrease it especially in the second season. N % of branches showed a contra trend when variances in N % were not significant in both seasons.

Data of N-uptake ( Table, 10 ) also showed that increasing levels of N-application from 0 up to 120 Kg N/fed. gradually increased N-uptake in leaves and / or branches in both seasons, with no significant differences up to 240 Kg N/fed. and then decreased at 300 Kg N/fed..This increment of N % and N-uptake by increasing levels of N-fertilizer could be referred to the increase of available-N in soil as a result of N-fertilization which consequently increased tomato plant foliage and roots and consequently increased minerals uptake. These results agree with Hargitai and Vass ( 1976 ) ; Kanazirska and

Boboshevska ( 1981 ). They reported that significant positive correlation was found between soil N-content and leaf N-content. Moreover, El-Aela ( 1988 ) reported that urea application up to 120 Kg N/fed. increased N-content of tomato leaves however, heavy urea application at 240 Kg N/fed. decreased leaf N-content.

Concerning $NO_3$-N accumulation in plant tissues data in Table (9) showed that $NO_3$-N % of leaves and branches were increased gradually and significantly by increasing levels of N-application from 0, 60, 120, 180, 240 and 300 Kg N/fed.. This trend was true in both seasons and could be referred to the normal accumulation of excess N-uptake as nitrates after N-assimilation. Therefore, the highest $NO_3$-N accumulation was found in plants fertilized with the highest N-level; 300 Kg N/fed.. This explanation is in harmony with the results of Minotti ( 1975 ); Pill et al ( 1978 ); Ikeda and Osawa ( 1983 ) and Magalhaes and Wilcox ( 1984 ).

Respecting P-content, data in Table ( 9) showed that P % of leaves and branches were not significantly affected by increasing level of N-application in both seasons except in the first season when P % of branches was increased by N-application within all levels than the control.

Concerning P-uptake Table ( 10 ) showed that increasing level of nitrogen application from 0 up to 60 Kg N/fed. significantly increased P-uptake in leaves and total plant foliage in the first season with no significant differences due to adding higher levels of N-fertilizer. Data also showed that P-uptake in branches gradually increased by increasing level of N-application up to 180 Kg N/fed. and then decreased at higher levels of N-application as shown in the first season. As for the second season data also showed the same trend; P-uptake in leaves, branches and total plant foliage were gradually increased by increasing level of N-application from 0 up to 120 Kg N/fed. with no significant differences between 120 and 180 Kg N/fed. and then decreased with adding higher levels of nitrogen fertilizer. The non significant effect of N-application on P % could be referred to the high growth induced by increasing levels of N-fertilizer which increased P-uptake but did not significantly effected P %. Although phosphorus was added at a standard level to all treatments; 64 Kg $P_2O_5$/fed. but it was clear that increasing levels of N-fertilizer improved plant growth and P-uptake, however excess level of N-application at 300 Kg N/fed. decreased plant growth and consequently decreased N, P and K uptake of plant organs.

As for K-content of leaves data in Tables ( 9, 10 ) showed that K % was significantly increased by N-application and reached the maximum increase at 120 or 180 Kg N/fed. depending on plant organ and growing season. Whereas K-uptake of leaves and / or branches were gradually and significantly increased by increasing levels of N-fertilizer from 0 up to 120 and 180 Kg N/fed. as shown in the second and first seasons, respectively. This improvement in K-uptake by increasing levels of N-fertilizer could be referred to the stimulating effect of N-fertilizer on plant growth as well as K-uptake.

### 4.1.2.6. Effect of form within level of N-application on mineral content of tomato plant foliage at fruit setting stage.

Data in Tables ( 11 and 12 ) showed that N %, $NO_3$-N and N-uptake in leaves and /or branches were not significantly differed by the interaction between N-source within levels in the first season. However, in the second season, N % in leaves reached the maximum with 120 Kg N/fed. as ammonium nitrate and 240 Kg N/fed. as urea fertilizer, but N % in branches was not significantly affected by such treatments of the interaction between N-source within levels. $NO_3$-N accumulation in leaves and branches was increased gradually and significantly by increasing level of N-application within both sources especially in the second season. Moreover, the effect of ammonium nitrate application on $NO_3$-N accumulation of plant tissues was more clear than that of urea.

These results agrees with Pill and Lambeth ( 1977 ). They found that $NH_4$-N resulted in reduced shoot and root concentration of $NO_3$-N as compared with plants received $NO_3$-N. Ikeda and Osawa ( 1983 ); Magalhaes and Wilcox (1984) and Kanazirska and Boboshevsk ( 1981 ) found a high positive correlation between soil-N content and leaf $NO_3$-N content.

Concerning P-content, data showed that P % and P-uptake in leaves and /or branches were not significantly affected by the interaction between N-source within N-level in both seasons except for P-uptake in branches in the first season, when increased by increasing level of urea application up to 180 Kg N/fed. and levels of ammonium nitrate up to 240 Kg N/fed.

**Table (11): NO3-N, N, P and K concentration of tomato plant foliage, 70 days after transplanting ( second sample ) as affected by N-source within N-level, during the seasons of 1993 and 1994.**

**Early summer season, 1993**

| Treatments | | Leaves | | | | Branches | | | |
|---|---|---|---|---|---|---|---|---|---|
| N-source | Kg N/fed. | NO3-N % | N % | P % | K % | NO3-N % | N % | P % | K % |
| Urea | 0 | 0.087 | 3.50 | 0.31 | 3.83 | 0.111 | 3.33 | 0.21 | 3.50 |
| | 60 | 0.095 | 3.66 | 0.34 | 4.50 | 0.135 | 3.50 | 0.24 | 4.00 |
| | 120 | 0.127 | 4.00 | 0.33 | 4.66 | 0.182 | 3.66 | 0.27 | 4.16 |
| | 180 | 0.182 | 4.33 | 0.34 | 5.16 | 0.230 | 3.66 | 0.26 | 4.50 |
| | 240 | 0.254 | 4.83 | 0.35 | 5.16 | 0.309 | 4.16 | 0.24 | 4.16 |
| | 300 | 0.294 | 4.33 | 0.33 | 4.83 | 0.349 | 3.83 | 0.25 | 4.00 |
| Amm. nitrate | 0 | 0.087 | 3.50 | 0.31 | 3.83 | 0.111 | 3.33 | 0.21 | 3.50 |
| | 60 | 0.103 | 4.50 | 0.35 | 4.83 | 0.159 | 3.83 | 0.25 | 4.16 |
| | 120 | 0.167 | 5.16 | 0.36 | 4.83 | 0.214 | 4.16 | 0.27 | 4.33 |
| | 180 | 0.238 | 5.33 | 0.35 | 5.83 | 0.278 | 4.16 | 0.26 | 4.50 |
| | 240 | 0.317 | 5.00 | 0.36 | 5.66 | 0.357 | 3.66 | 0.25 | 4.33 |
| | 300 | 0.333 | 5.16 | 0.35 | 5.83 | 0.381 | 3.33 | 0.28 | 4.16 |
| L.S.D. at 0.05 | | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. |

**Early summer season, 1994**

| Treatments | | Leaves | | | | Branches | | | |
|---|---|---|---|---|---|---|---|---|---|
| N-source | Kg N/fed. | NO3-N % | N % | P % | K % | NO3-N % | N % | P % | K % |
| Urea | 0 | 0.079 | 3.16 | 0.30 | 3.66 | 0.096 | 3.50 | 0.25 | 3.16 |
| | 60 | 0.095 | 3.66 | 0.33 | 4.16 | 0.145 | 3.66 | 0.28 | 3.83 |
| | 120 | 0.197 | 3.83 | 0.33 | 4.50 | 0.225 | 3.83 | 0.29 | 4.33 |
| | 180 | 0.273 | 4.33 | 0.34 | 4.66 | 0.298 | 4.00 | 0.27 | 4.83 |
| | 240 | 0.354 | 5.00 | 0.31 | 4.83 | 0.395 | 4.33 | 0.26 | 4.33 |
| | 300 | 0.483 | 4.50 | 0.32 | 4.66 | 0.528 | 4.00 | 0.25 | 4.16 |
| Amm. nitrate | 0 | 0.079 | 3.16 | 0.30 | 3.66 | 0.096 | 3.50 | 0.25 | 3.16 |
| | 60 | 0.104 | 4.50 | 0.33 | 4.50 | 0.169 | 4.00 | 0.26 | 4.33 |
| | 120 | 0.236 | 5.50 | 0.33 | 4.83 | 0.251 | 4.33 | 0.27 | 4.66 |
| | 180 | 0.319 | 5.16 | 0.34 | 5.00 | 0.356 | 4.50 | 0.26 | 4.83 |
| | 240 | 0.436 | 5.50 | 0.32 | 4.83 | 0.492 | 3.83 | 0.27 | 4.33 |
| | 300 | 0.582 | 4.66 | 0.32 | 4.66 | 0.616 | 3.66 | 0.25 | 4.00 |
| L.S.D. at 0.05 | | 0.041 | 0.68 | N.S. | N.S. | 0.041 | N.S. | N.S. | N.S. |

**Table (12): N, P and K uptake of tomato plant foliage, 70 days after transplanting ( second sample ) as affected by N-source within N-level, during the early summer seasons of 1993 and 1994.**

**Early summer season, 1993**

| Treatments | | Leaves ( mg/plant ) | | | Branches ( mg/plant ) | | | Total foliage (mg/plant) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| N-source | Kg N/fed. | N | P | K | N | P | K | N | P | K |
| Urea | 0 | 391.60 | 34.60 | 430.20 | 145.40 | 9.10 | 154.60 | 537.00 | 43.70 | 584.80 |
| | 60 | 547.00 | 51.90 | 677.10 | 209.00 | 14.70 | 242.70 | 756.00 | 66.60 | 919.80 |
| | 120 | 579.60 | 48.60 | 674.70 | 255.30 | 19.10 | 287.60 | 834.90 | 67.70 | 962.30 |
| | 180 | 675.50 | 53.60 | 816.20 | 345.40 | 24.60 | 420.70 | 1020.90 | 78.20 | 1236.90 |
| | 240 | 774.10 | 56.70 | 830.40 | 245.10 | 13.90 | 244.00 | 1019.20 | 70.60 | 1074.40 |
| | 300 | 685.70 | 47.70 | 691.70 | 246.10 | 16.70 | 262.90 | 931.80 | 64.40 | 954.60 |
| Amm. nitrate | 0 | 391.60 | 34.60 | 430.20 | 145.40 | 9.10 | 154.60 | 537.00 | 43.70 | 584.80 |
| | 60 | 535.90 | 61.50 | 571.70 | 219.50 | 14.70 | 239.10 | 755.40 | 76.20 | 810.80 |
| | 120 | 810.30 | 56.50 | 760.90 | 272.60 | 17.50 | 283.20 | 1082.90 | 74.00 | 1044.10 |
| | 180 | 978.80 | 65.50 | 1071.00 | 304.90 | 19.10 | 330.90 | 1283.70 | 84.60 | 1401.90 |
| | 240 | 916.40 | 66.60 | 1032.70 | 314.60 | 21.20 | 370.70 | 1231.00 | 87.80 | 1403.40 |
| | 300 | 747.30 | 58.40 | 973.90 | 232.20 | 19.30 | 289.40 | 979.50 | 77.70 | 1263.30 |
| **L.S.D. at 0.05** | | **N.S.** | **N.S.** | **194.80** | **N.S.** | **2.80** | **88.70** | **N.S.** | **N.S.** | **219.55** |

**Early summer season, 1994**

| Treatments | | Leaves ( mg/plant ) | | | Branches ( mg/plant ) | | | Total foliage (mg/plant) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| N-source | Kg N/fed. | N | P | K | N | P | K | N | P | K |
| Urea | 0 | 443.90 | 42.40 | 511.60 | 601.80 | 42.00 | 541.80 | 1045.70 | 84.40 | 1053.40 |
| | 60 | 543.10 | 49.20 | 615.20 | 756.30 | 58.40 | 792.90 | 1299.40 | 107.60 | 1408.10 |
| | 120 | 658.60 | 57.50 | 767.50 | 1002.90 | 75.90 | 1132.80 | 1661.50 | 133.40 | 1900.30 |
| | 180 | 778.30 | 62.00 | 832.00 | 1070.40 | 72.60 | 1282.20 | 1848.70 | 134.60 | 2114.20 |
| | 240 | 779.00 | 49.50 | 757.00 | 1011.60 | 62.00 | 1026.00 | 1790.60 | 111.50 | 1783.00 |
| | 300 | 696.90 | 50.00 | 720.50 | 906.50 | 57.90 | 942.40 | 1603.40 | 107.90 | 1662.90 |
| Amm. nitrate | 0 | 443.90 | 42.40 | 511.60 | 601.80 | 42.00 | 541.80 | 1045.70 | 84.40 | 1053.40 |
| | 60 | 706.50 | 51.80 | 706.50 | 1083.50 | 71.00 | 1162.90 | 1790.00 | 122.80 | 1869.40 |
| | 120 | 991.30 | 60.70 | 875.70 | 1442.30 | 88.90 | 1537.60 | 2433.60 | 149.60 | 2413.30 |
| | 180 | 975.40 | 64.10 | 945.60 | 1545.80 | 90.70 | 1675.40 | 2521.20 | 154.80 | 2621.20 |
| | 240 | 831.00 | 49.50 | 732.10 | 850.00 | 60.40 | 972.70 | 1681.00 | 109.90 | 1704.80 |
| | 300 | 676.20 | 46.90 | 677.70 | 813.20 | 56.00 | 892.40 | 1489.40 | 102.90 | 1570.10 |
| **L.S.D. at 0.05** | | **123.30** | **N.S.** | **N.S.** | **324.30** | **N.S.** | **N.S.** | **350.95** | **N.S.** | **300.82** |

Concerning potassium % of leaves or branches data in the same Tables showed that K % was not significantly affected by the interaction between N-source within N-level in both seasons. Whereas, K-uptake in leaves and branches in the second season showed the same trend. Data of the first season showed that adding 180 Kg N/fed. of ammonium nitrate or urea resulted the highest K-uptake of leaves and or branches. This improvements in K-uptake by increasing levels of nitrogen application may be due to the stimulating effect of N-fertilizer on plant growth as well as K-uptake.

### 4.1.2.7. Nitrate accumulation in tomato plant organs as affected by source within level of N-application.

Results in Tables (7, 11&16) and Figs (1, 2 & 3) showed that

1- Nitrate-N accumulation was higher in all plant organs; stem, leaf and fruit in plants supplied with ammonium nitrate as compared with those supplied with urea.

2- $NO_3$-N accumulation was higher in branches ( 1904-8171 ppm ), medium in leaves ( 1190-7140 ppm ) and very low in fruits ( 1-35.8 ppm ).

3- Results also showed that $NO_3$-N accumulation in branches and leaves was high ( Fig, 1 ) at flowering stage ( 1190- 8171 ppm ) and then depressed when plants go to fruit setting stage ( 870-3808 ppm ) as shown in Fig ( 2 ).

These results are completely agree with those of Pill and Lameth ( 1977 ). They found that $NH_4$-N resulted in reduced shoot and root concentration of $NO_3$-N as compared with plant received $NO_3$-N. Ikeda and Osawa ( 1983 ); Magathaes and Wilcox (1984) and Kanazirska and Boboshevska ( 1981 ) found a high positive correlation between soil-N content and leaf $NO_3$-N content. Moreover, Gabal ( 1983 ) mentioned similar result on sweet pepper.

**Fig ( 1 ): Effect of N-source within N-level on NO3-N accumulation in branches and leaves of tomato plant at flowering stage.**

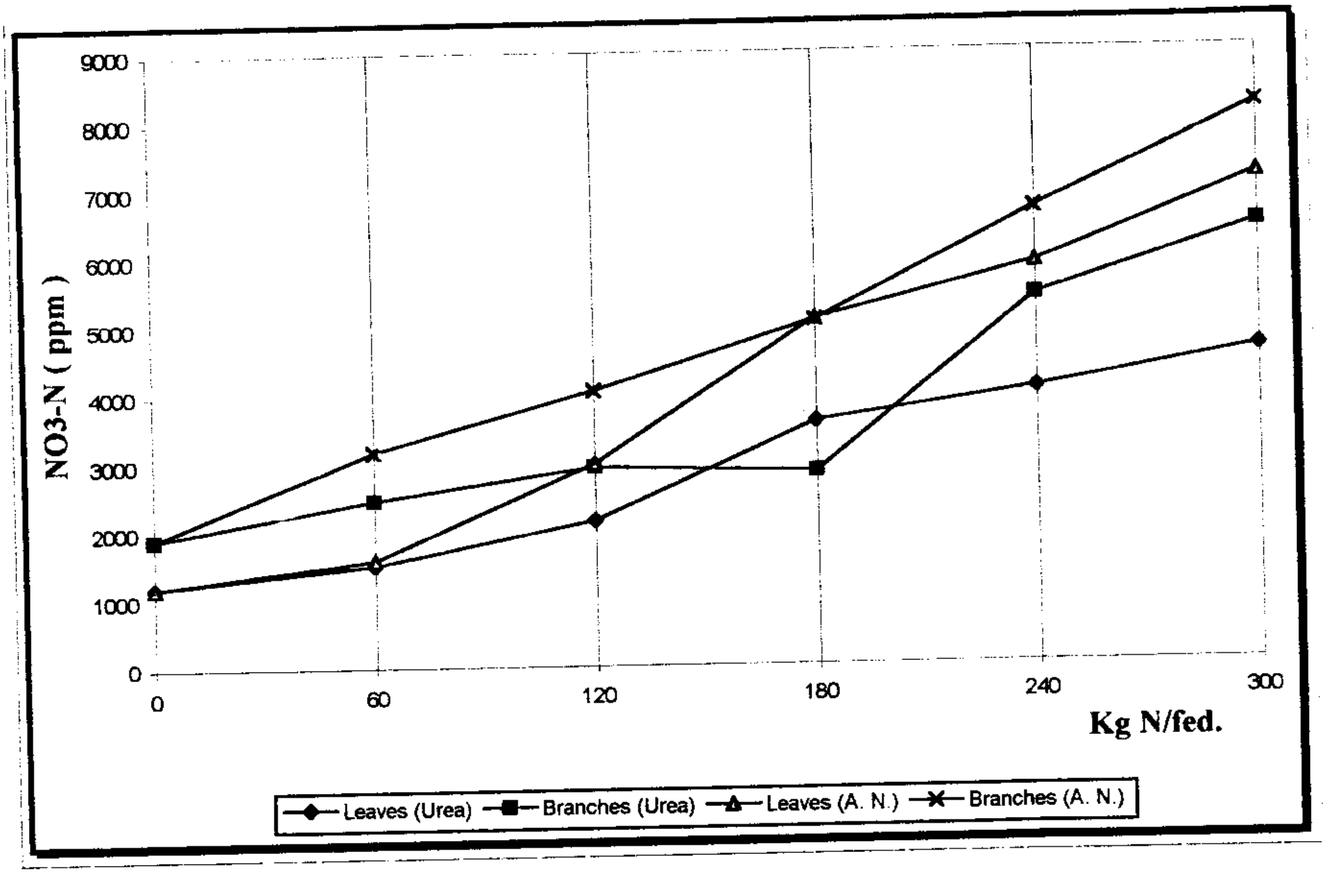



Fig (1)

**Fig ( 2 ): Effect of N-source within N-level on NO3-N accumulation in branches and leaves of tomato plant at fruit setting stage.**

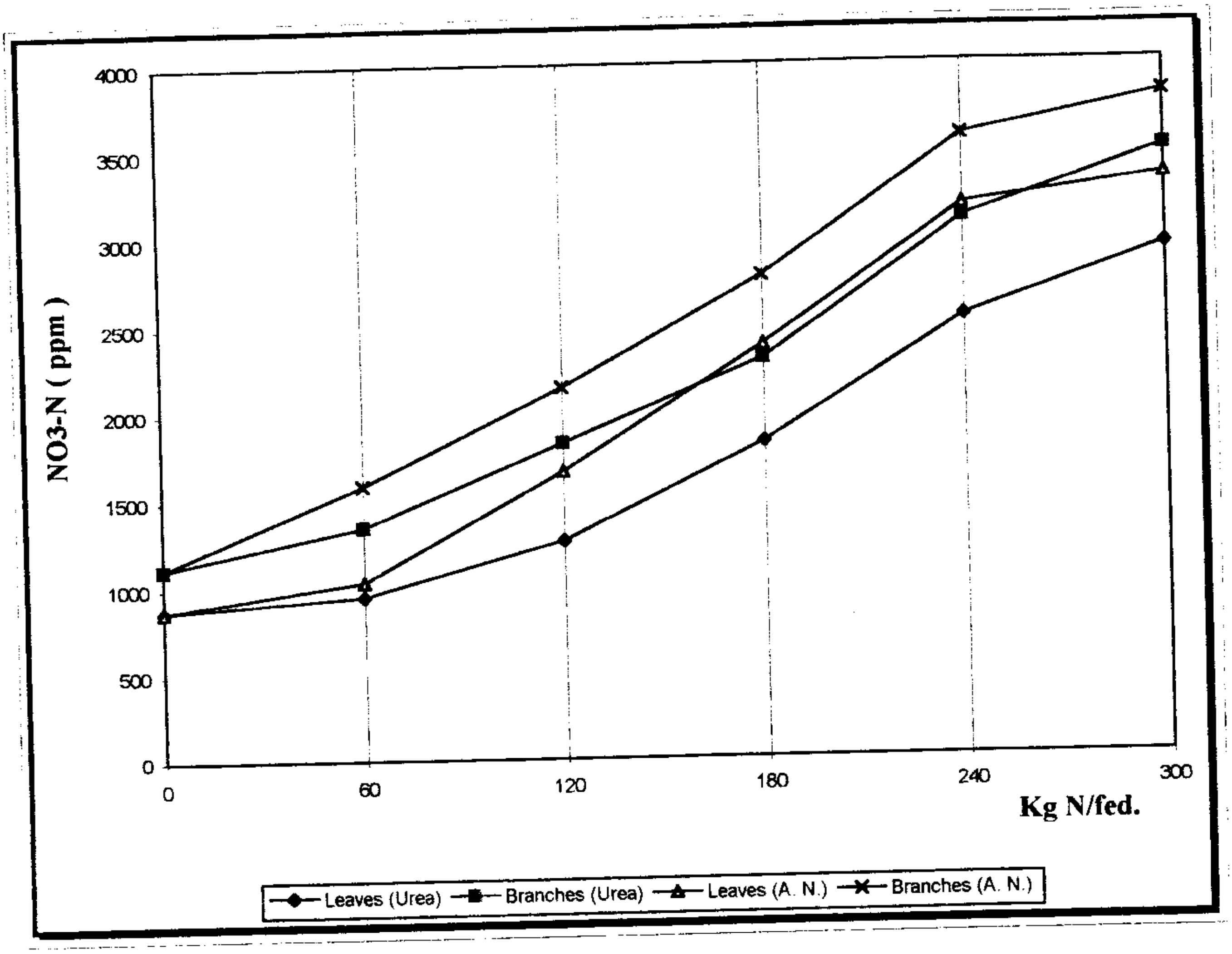


**Fig ( 3 ): Effect of N-source within N-level on NO3-N accumulation in tomato fruit.**

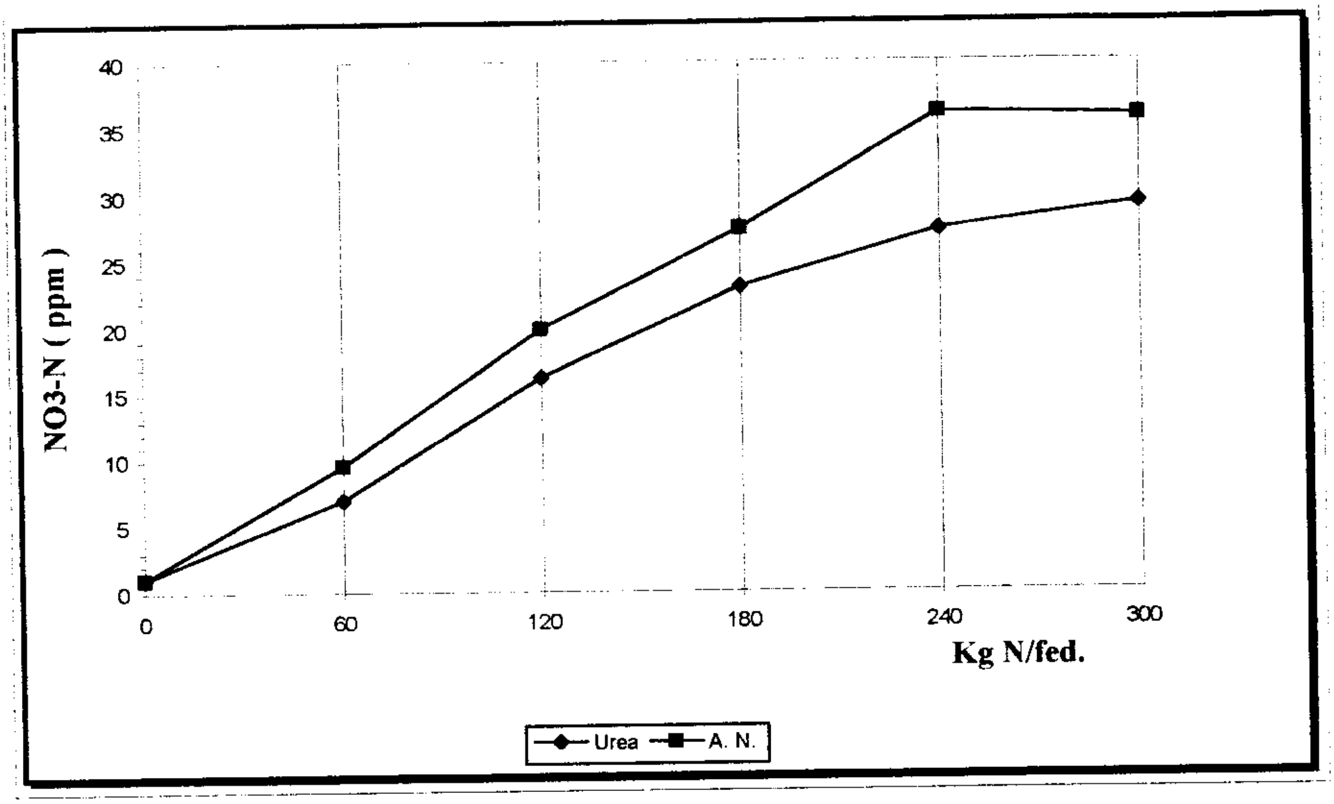



Fig (3)

The high accumulation of $NO_3$-N in plants supplied with ammonium nitrate may be referred to that ammonium nitrate fertilizer contain 50 % of its nitrogen as nitrate form but urea contains its nitrogen as amide form. The greet depression of $NO_3$-N in plant organs at fruit setting stage as compared with that at flowering stage may be due to the translocation of nitrates from leaves and stems to recover the requirements of fruit development. Added to that the considerable development in plant growth expressed as fresh and dray weight of plant foliage may be delute the concentration of nutrients including $NO_3$-N concentration in plant leaves and / or branches at fruit setting stage than that at flowering stage.

### 4.1.3. Fruit yield of tomato as affected by source and levels of nitrogen fertilizer:

#### 4.1.3.1. Effect of source of N-application on tomato fruit yield.

Data showed the effect of N-source on tomato fruit yield (Table 13) revealed that early, marketable and total yield were increased by ammonium nitrate application as compared with urea in the second season. Although such
trends were detected in the first season, but variances in early marketable and total yield due to N-source were not significant. Concerning the unmarketable yield, it was not significantly affected by source of nitrogen application in the second season however urea led to a higher unmarketable yield than that of ammonium nitrate in the first season.

These results may be due to that ammonium nitrate increased vegetative growth as compared with urea fertilization which consequently increased early and total yield production, added to that adverse effect of urea on yield earliness.

**Table (13): Tomato fruit yield and its components as affected by N-source or N-level during the seasons of 1993 and 1994.**

**Early summer season, 1993**

| Treatments | Early yield ton/fed. | Marketable yield ton/fed. | Unmarketable yield ton/fed. | Total yield ton/fed. |
|---|---|---|---|---|
| **N-source** | | | | |
| Urea | 1.42 | 7.70 | 0.84 | 8.54 |
| Amm. nitrate | 2.66 | 7.94 | 0.72 | 8.66 |
| **L.S.D. at 0.05** | **N.S.** | **N.S.** | **0.07** | **N.S.** |
| **Kg/fed.** | | | | |
| 0 | 1.22 | 7.08 | 1.70 | 8.78 |
| 60 | 1.45 | 7.96 | 0.66 | 8.62 |
| 120 | 1.74 | 9.21 | 0.93 | 10.14 |
| 180 | 1.20 | 8.62 | 0.89 | 9.51 |
| 240 | 1.21 | 7.90 | 0.83 | 8.73 |
| 300 | 1.13 | 6.15 | 0.79 | 6.94 |
| **L.S.D. at 0.05** | **0.39** | **0.78** | **0.12** | **0.82** |

**Early summer season, 1994**

| Treatments | Early yield ton/fed. | Marketable yield ton/fed. | Unmarketable yield ton/fed. | Total yield ton/fed. |
|---|---|---|---|---|
| **N-source** | | | | |
| Urea | 1.99 | 8.20 | 0.60 | 8.80 |
| Amm. nitrate | 2.74 | 10.65 | 0.63 | 11.28 |
| **L.S.D. at 0.05** | 0.36 | **0.91** | N.S. | **0.85** |
| **Kg/fed.** | | | | |
| 0 | 2.21 | 7.53 | 0.59 | 8.12 |
| 60 | 2.86 | 10.33 | 0.62 | 10.95 |
| 120 | 2.62 | 11.34 | 0.68 | 12.02 |
| 180 | 2.55 | 10.60 | 0.63 | 11.23 |
| 240 | 2.07 | 8.66 | 0.51 | 9.17 |
| 300 | 1.85 | 8.08 | 0.67 | 8.75 |
| **L.S.D. at 0.05** | **0.62** | **1.57** | **N.S.** | **1.47** |

This explanation agrees with Pill and Lambeth ( 1977 and 1980 ); Ganmore-Neumann and Kafkafi ( 1980 ); Krishchenko ( 1981 ) and Kooner and Randhawa ( 1983 ). They reported that tomato fruit yield was higher with ammonium nitrate than with urea. Moreover, Gabal ( 1983 ) registrated the adverse effect of urea fertilizer on growth of sweet pepper as compared with ammonium nitrate in sandy soil.

Whereas, tomato experiments here in this work were grown in a clayloam soil which had enough organic matter to adsorb the $NH_4^+$ ions released from urea hydrolysis. It seems that 1993 season was little colder than 1994 i.e. plant growth and nutritents uptake were a little pit lower in 1993 than that of 1994, as shown in Tables ( 1 & 3 and 6 & 10 ). There by we could explain the insignificant variance in fruit yield and its components in 1993 due to the source of N-fertilizer.

## 4.1.3.2. Effect of level of N-application on tomato fruit yield.

Data in Table ( 13 ) showed that early and marketable yield were increased by increasing level of N-application from 0 up to 60 Kg N/fed. as shown in both seasons. Whereas increasing level of N-application up to 120 Kg N/fed. increased marketable and total yield but did not increase early yield as shown in the first season. Although the same trend was detected in the second one but variances in between 60 and 120 Kg N/fed. were not significant i.e. no significant differences between 60 and 120 and 180 Kg N/fed. were detected between N-levels for early, marketable or total yield in the second season. Results also showed that higher levels of nitrogen application ( 240 and 300 Kg N/fed. ) decreased early, marketable and total yield as a general trend for both seasons. As for the unmarketable yield it was decreased by N-application within all levels as compared with the control in the first season. Adding 120, 180 or 240 Kg N/fed. produced similar unmarketable yield as shown in the first season; however in the second one N-levels had no significant effect on the unmarketable yield. ***As a general trend data showed that 60 Kg N/fed. gave the best early yield and 120 Kg N/fed. gave the highest marketable and total fruit yield.***

The favorable effect of moderate level of N-application ( 60 or 120 Kg N/fed. ) on tomato early yield have been mentioned by Atherton and Rudich (1986) and Dimitrof and Rankov ( 1976 ). They reported that the highest early, total and marketable yield were produced by 240 Kg N/ha. but application of 480 Kg N/ha. reduced yield earliness. And could be referred to the moderate vegetative growth which led to an early flowering and consequently higher early yield. On the other hand, the heavy N-application ( 240 and 300 Kg N/fed. ) elongated the vegetative growth period, delayed flowering and decreased early yield production. This result is in harmony with Anand and Muthurishnan ( 1974/a ) and Doss et al ( 1975 ).

Results of marketable and total yield showed that the moderate level of N-application stimulated vegetative growth and mineral contents in tomato plant organs. This moderate level was concedred as optimum N-level ( 120 Kg N/fed. ) for this studies. On the other hand, heavy levels of N-application depressed vegetative growth and N, P and K contents of tomato plant organs. Results of total and marketable yield are completely agree with Anand and Muthurishnan ( 1974/a ); Doss et al ( 1975 ). They reported that increasing N-rate from 0-130 Kg N/ha. increased tomato fruit yield and higher level up to 195 Kg N/ha. had a little effect on fruit yield and increasing N-rate up to 260 Kg N/ha. decreased fruit yield than that of the lower ones. Moreover, Oswiecimski ( 1981 ); Kooner and Randhawa ( 1983 ); Midan et al ( 1985 ) and El-Aela (1988) found that heavy urea application considerably decreased tomato fruit yield as compared with the moderate level of urea application.

### 4.1.3.3. Effect of N-source within N-level on tomato fruit yield.

Concerning the interaction effect between N-source and N-level, data in Table ( 14 ) showed that early, marketable, unmarketable and total yield were not significantly affected by this interaction treatments in both seasons except for the unmarketable yield in the first season. Data showed that 120 or 180 Kg N/fed. as ammonium nitrate produced higher unmarketable yield than all levels of ammonium nitrate. This result may be referred to the high total yield production of these treatments which increased the unmarketable yield by weight. Moreover, adding 120 up to 300 Kg N/fed. as urea gave similar unmarketable yield and higher than that of plant supplied with 60 Kg N/fed. as urea or the control. These results means that theire were no significant effect between N-source within N-level on early, marketable and total yield under the condition of this experiment was grown in clay loam soil, at early summer season using early tomato cultivar such UC-97-3 i.e. This clayloam soil contains enough organic matter to buffer the soil reaction and to adsorb the $NH_4^+$ ion released after urea hydrolysis which depressed the superiority of one N-source than the other. Added to that ammonium nitrate contains 50 % of its nitrogen as $NH_4$+ and 50 % as $NO_3$. Although heavy N-application ( 300 Kg N/fed. ) as urea or ammonium nitrate seemed to depress yield and its components but variances failed to reach the level of significance in both seasons. Therefore, it is worthy to make stress on the main effect of these to factors ( N-source or N-level ) separately which showed that the best level of nitrogen was 120 Kg N/fed. as ammonium nitrate which gave the highest production of early, marketable and total yield. These results are in harmony with the results obtained by Anand and Muthurishnan ( 1974/a ) and Doss et al ( 1975 ) as previously discussed.

**Table (14): Tomato fruit yield and its components as affected by N-source within N-level during the seasons of 1993 and 1994.**

**Early summer season, 1993**

| Treatments | | Early yield | Marketable yield | Unmarketable yield | Total yield |
|---|---|---|---|---|---|
| N-source | Kg N/fed. | ton/fed. | ton/fed. | ton/fed. | ton/fed. |
| Urea | 0 | 1.22 | 7.08 | 0.57 | 7.64 |
| | 60 | 1.67 | 7.55 | 0.61 | 8.17 |
| | 120 | 1.73 | 9.10 | 0.97 | 10.07 |
| | 180 | 1.32 | 8.39 | 1.01 | 9.40 |
| | 240 | 1.33 | 7.62 | 0.97 | 8.59 |
| | 300 | 1.25 | 6.47 | 0.87 | 7.34 |
| Amm. nitrate | 0 | 1.22 | 7.08 | 0.57 | 7.64 |
| | 60 | 1.23 | 8.36 | 0.71 | 9.07 |
| | 120 | 1.76 | 9.32 | 0.89 | 10.21 |
| | 180 | 1.09 | 8.86 | 0.77 | 9.63 |
| | 240 | 1.10 | 8.19 | 0.69 | 8.88 |
| | 300 | 1.03 | 5.84 | 0.71 | 6.55 |
| **L.S.D. at 0.05** | | **N.S.** | **N.S.** | **0.17** | **N.S.** |

**Early summer season, 1994**

| Treatments | | Early yield | Marketable yield | Unmarketable yield | Total yield |
|---|---|---|---|---|---|
| N-source | Kg N/fed. | ton/fed. | ton/fed. | ton/fed. | ton/fed. |
| Urea | 0 | 2.21 | 7.53 | 0.59 | 8.13 |
| | 60 | 2.41 | 8.83 | 0.59 | 9.41 |
| | 120 | 2.13 | 9.34 | 0.69 | 10.03 |
| | 180 | 2.17 | 9.05 | 0.64 | 9.69 |
| | 240 | 1.73 | 7.49 | 0.53 | 8.01 |
| | 300 | 1.25 | 7.01 | 0.58 | 7.59 |
| Amm. nitrate | 0 | 2.21 | 7.53 | 0.59 | 8.13 |
| | 60 | 3.31 | 11.84 | 0.66 | 12.50 |
| | 120 | 3.11 | 13.35 | 0.69 | 14.03 |
| | 180 | 2.93 | 12.16 | 0.61 | 12.77 |
| | 240 | 2.41 | 9.85 | 0.49 | 10.35 |
| | 300 | 2.45 | 9.15 | 0.77 | 9.91 |
| **L.S.D. at 0.05** | | **N.S.** | **N.S.** | **N.S.** | **N.S.** |

## 4.1.4. Tomato fruit quality as affected by source and level of N-fertilizer:

### 4.1.4.1. Effect of N-source on tomato fruit quality.

Data in Table ( 15 ) showed that fruit length and average fruit weight were not significantly affected by source of N-application in both seasons. Whereas, ammonium nitrate application slightly increased tomato fruit diameter as compared with urea application only in the first season, but not in the second one.

Respecting with fruit dry weight percentage, it was significantly increased by urea application as compared with ammonium nitrate in the first season but variances failed to reach the significant level in the second one. Data also showed that TSS% and $NO_3$-N content of tomato fruit tissues were significantly increased in plant supplied with ammonium nitrate than that of urea in both seasons, except for TSS% in the second season when variances failed to be a significant. Total acidity of fruit juice was significantly increased by ammonium nitrate application as compared with urea in the first season, whereas the opsit trend was detected in the second one. Vitamin-C content of fruits was significant increased with urea application in the first season but variances failed to reach the significant level in the second one.

**Table (15): Tomato fruit quality as affected by N-source or N-level during the seasons of 1993 and 1994.**

**Early summer season, 1993**

| Treatments | Fruit L. Cm. | Fruit D. Cm. | Fruit W. g/fruit | Fruit dry W. % | T.S.S. % | Total acidity mg/l. | Vitamin C mg/100cm3 | NO3-N ppm |
|---|---|---|---|---|---|---|---|---|
| **N-source** | | | | | | | | |
| Urea | 5.45 | 5.48 | 92.52 | 5.41 | 3.40 | 596.94 | 27.13 | 17.30 |
| Amm. nitrate | 5.40 | 5.65 | 97.51 | 5.34 | 3.70 | 629.17 | 24.28 | 21.60 |
| **L.S.D. at 0.05** | **N.S.** | **0.11** | **N.S.** | **0.04** | **0.15** | **5.00** | **1.04** | **2.02** |
| **Kg/fed.** | | | | | | | | |
| 0 | 5.43 | 5.63 | 96.56 | 5.38 | 3.06 | 626.33 | 17.20 | 1.00 |
| 60 | 5.51 | 5.56 | 92.13 | 5.24 | 3.50 | 588.66 | 26.46 | 8.38 |
| 120 | 5.35 | 5.66 | 97.35 | 5.24 | 3.73 | 617.50 | 24.80 | 18.07 |
| 180 | 5.56 | 5.55 | 100.96 | 5.17 | 3.93 | 660.33 | 32.70 | 25.23 |
| 240 | 5.35 | 5.53 | 101.03 | 5.48 | 3.56 | 562.00 | 27.75 | 31.77 |
| 300 | 5.35 | 5.48 | 82.05 | 5.74 | 3.50 | 623.50 | 25.31 | 32.52 |
| **L.S.D. at 0.05** | **N.S.** | **N.S.** | **12.52** | **0.06** | **0.26** | **8.66** | **1.80** | **3.49** |

**Early summer season, 1994**

| Treatments | Fruit L. Cm. | Fruit D. Cm. | Fruit W. g/fruit | Fruit dry W. % | T.S.S. % | Total acidity mg/l. | Vitamin C mg/100cm3 | NO3-N ppm |
|---|---|---|---|---|---|---|---|---|
| **N-source** | | | | | | | | |
| Urea | 5.66 | 5.43 | 82.63 | 6.05 | 4.00 | 761.42 | 24.75 | 17.72 |
| Amm. nitrate | 5.51 | 5.28 | 85.23 | 5.84 | 4.06 | 706.04 | 23.71 | 20.18 |
| **L.S.D. at 0.05** | N.S. | N.S. | N.S. | N.S. | N.S. | **35.53** | N.S. | **1.62** |
| **Kg/fed.** | | | | | | | | |
| 0 | 5.56 | 5.30 | 70.86 | 5.33 | 3.93 | 760.30 | 20.26 | 1.33 |
| 60 | 5.63 | 5.31 | 100.70 | 5.45 | 3.93 | 695.90 | 24.21 | 8.17 |
| 120 | 5.65 | 5.51 | 91.18 | 6.00 | 3.86 | 724.01 | 24.38 | 17.87 |
| 180 | 5.76 | 5.43 | 82.41 | 6.10 | 4.10 | 731.30 | 25.73 | 26.23 |
| 240 | 5.50 | 5.45 | 82.76 | 6.59 | 4.40 | 738.83 | 25.26 | 30.23 |
| 300 | 5.40 | 5.16 | 75.70 | 6.22 | 3.96 | 751.98 | 25.51 | 29.88 |
| **L.S.D. at 0.05** | N.S. | **N.S.** | **16.57** | **0.63** | **0.32** | **N.S.** | **2.44** | **2.81** |

### 4.1.4.2. Effect of level of N-application on tomato fruit quality.

Data in Table ( 15 ) showed that fruit length, diameter and fruit shape index were not significantly affected by levels of N-application in both seasons. It seems that fruit dimensions of UC-97-3 were not significantly affected either by source or level of N- application. With respect to average fruit weight, it was increased by increasing N-application than the control especially
in the second season. Heavy N-application at 180 and 240 Kg N/fed. in the first season and 300 Kg N/fed. in both seasons decreased average fruit weight. This result may be due to the adverse effect of heavy N-application on plant growth and nutrients uptake as mentioned in Tables ( 1 & 3 and 6 & 10 ). However, at a moderate N-levels 120 or 180 Kg N/fed. fruit yield was increased by weight and number and therefore average fruit weight was decreased. This result agree with those of Al-Afifi et al ( 1991 ). They reported that increasing level of N-application from 50, 100 and 150 Kg N/ha. increased fruit weight but 200 Kg N/ha. decreased it.

According to percentage of fruit dry weight, it was gradually decreased by increasing level of N-application from 0, 60, 120 and 180 Kg N/fed. and then increased at 240 or 300 Kg N/fed as shown in the first season. In the second one an adverse trend was detected. This result may be due to that cv. UC-97-3 is a fleshy fruit, low in moisture content as compared with the juicy cultivars.

Data of tomato juice showed that. TSS %, total acidity and vitamin-C were increased by increasing level of N-application from 0, 60 up to 120 or 180 Kg N/fed. in both seasons except for total acidity in the second season when variances failed to reach the level of significance. As for $NO_3$-N content of tomato fruit, it was increased gradually and significantly by increasing levels of N-application from 0, 60, 120, 180, 240 and 300 Kg N/fed. Therefore, the maximum $NO_3$-N accumulation in tomato fruit resulted by application of the highest level of nitrogen ( 300 Kg N/fed. ) in both seasons. These results are in agreement with those of Hargitai and Vass ( 1976 ); Miyazaki and Kunisato ( 1975 ) and Magalhaes and Wilcox ( 1984 ). They reported that $NO_3$-N accumulation in plant tissues is mainly affected by the concentration of $NO_3$ in the soil or growth media.

### 4.1.4.3. Effect of source within level of N-application on tomato fruit quality.

Data in Table ( 16 ) showed that fruit length and average fruit weight were not significantly affected by these interaction treatments. Fruit diameter was slightly improved by moderate N-application 60 or 120 Kg N/fed. but decreased by heavy N-application ( 240 or 300 Kg N/fed. ) especially from urea. Fruit diameter, fruit dry weight % and TSS % were not significantly affected by source within level of N-fertilizer in the second season. Whereas, data of the first season showed that heavy urea application ( 180, 240 and 300 Kg N/fed. ) decreased fruit diameter as compared with the lower levels or control. However fruit diameter was not affected by ammonium nitrate application within all levels as shown in the first season. Respecting with fruit dry weight %, it was improved by adding nitrogen within all levels and sources than the control and the highest values were obtained from plants supplied with 240 or 300 Kg N/fed. as urea or ammonium nitrate. This result may be due to that treatments received high nitrogen gave a relative low growth with less dry matter accumulation and consequently less dry matter content in fruits. Concerning with TSS %, plant supplied with 120-180 Kg N/fed. as urea or ammonium nitrate gave the highest TSS % of tomato juice as compared with other treatments or the control. Heavy application of urea at 240 or 300 Kg N/fed. decreased TSS % as compared with the lower levels.

**Table (16): Tomato fruit quality as affected by N-levels within N-source during the seasons of 1993 and 1994.**

**Early summer season, 1993**

| Treatments | | Fruit L. | Fruit D. | Fruit W. | Fruit dry W. | T.S.S | Total acidity | Vitamin C | NO3-N |
|---|---|---|---|---|---|---|---|---|---|
| N-source | Kg N/fed. | Cm. | Cm. | g/fruit | % | % | mg/l | mg/100cm3 | ppm |
| Urea | 0 | 5.43 | 5.63 | 96.56 | 5.38 | 3.06 | 626.33 | 17.20 | 1.00 |
| | 60 | 5.50 | 5.53 | 92.06 | 5.45 | 3.13 | 570.00 | 26.66 | 7.00 |
| | 120 | 5.33 | 5.53 | 92.93 | 5.10 | 3.73 | 624.00 | 26.90 | 16.20 |
| | 180 | 5.73 | 5.46 | 106.63 | 5.27 | 3.93 | 674.33 | 33.70 | 23.00 |
| | 240 | 5.30 | 5.43 | 86.93 | 5.46 | 3.26 | 551.66 | 32.60 | 27.30 |
| | 300 | 5.40 | 5.33 | 80.00 | 5.80 | 3.26 | 535.33 | 15.73 | 29.20 |
| Amm. nitrate | 0 | 5.43 | 5.63 | 96.56 | 5.38 | 3.06 | 626.33 | 17.20 | 1.00 |
| | 60 | 5.53 | 5.60 | 92.20 | 5.03 | 3.86 | 607.33 | 26.20 | 9.60 |
| | 120 | 5.36 | 5.80 | 101.76 | 5.37 | 3.73 | 611.00 | 22.70 | 19.90 |
| | 180 | 5.40 | 5.63 | 95.30 | 5.07 | 3.93 | 646.33 | 31.70 | 27.40 |
| | 240 | 5.40 | 5.63 | 115.13 | 5.51 | 3.86 | 572.33 | 22.90 | 36.10 |
| | 300 | 5.30 | 5.63 | 84.10 | 5.67 | 3.73 | 711.66 | 24.90 | 35.80 |
| **L.S.D. at 0.05** | | **N.S.** | **0.27** | **N.S.** | **0.09** | **0.36** | **12.25** | **2.53** | **18.65** |

**Early summer season, 1994**

| Treatments | | Fruit L. | Fruit D. | Fruit W. | Fruit dry W. | T.S.S | Total acidity | Vitamin C | NO3-N |
|---|---|---|---|---|---|---|---|---|---|
| N-source | Kg N/fed. | Cm. | Cm. | g/fruit | % | % | mg/l | mg/100cm3 | ppm |
| Urea | 0 | 5.56 | 5.30 | 70.86 | 5.33 | 3.93 | 760.30 | 20.26 | 1.33 |
| | 60 | 5.66 | 5.46 | 101.86 | 5.72 | 3.86 | 776.20 | 23.93 | 1.73 |
| | 120 | 5.70 | 5.63 | 86.56 | 6.22 | 3.80 | 708.40 | 26.00 | 17.03 |
| | 180 | 5.80 | 5.30 | 79.30 | 6.12 | 4.13 | 760.40 | 26.43 | 24.87 |
| | 240 | 5.60 | 5.43 | 77.66 | 6.73 | 4.26 | 774.93 | 25.93 | 28.07 |
| | 300 | 5.66 | 5.50 | 79.56 | 6.19 | 4.00 | 788.60 | 25.93 | 27.30 |
| Amm. nitrate | 0 | 5.56 | 5.30 | 70.86 | 5.33 | 3.93 | 760.30 | 20.26 | 1.33 |
| | 60 | 5.60 | 5.16 | 99.53 | 5.18 | 4.00 | 615.60 | 24.50 | 8.60 |
| | 120 | 5.60 | 5.40 | 95.80 | 5.78 | 3.93 | 739.50 | 22.76 | 18.70 |
| | 180 | 5.73 | 5.56 | 85.53 | 6.09 | 4.06 | 702.20 | 25.03 | 27.60 |
| | 240 | 5.40 | 5.46 | 87.80 | 6.44 | 4.53 | 703.20 | 24.60 | 32.40 |
| | 300 | 5.16 | 4.83 | 71.83 | 6.24 | 3.93 | 715.30 | 25.10 | 32.40 |
| **L.S.D. at 0.05** | | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **87.02** | **N.S.** | **20.10** |

Total acidity was significantly affected by the interaction treatments in both seasons, the highest value was recorded with the highest level of N-application of ammonium nitrate and urea in 1993 and 1994 respectively. As for $NO_3$-N accumulation in fruit tissues it was increased gradually and significantly by increasing level of N-application from ammonium nitrate or urea in both seasons. Therefore, the maximum $NO_3$-N accumulation in fruit tissues was associated with the highest N-level as ammonium nitrate followed by urea as shown in Fig ( 3).

Concerning vitamin-C content, data of the first season showed that N-application within all levels and sources increased vitamin-C content of tomato fruit than the control except at the high level of urea; 300 Kg N/fed. which depressed it . The highest results of vitamin-C content were found in plants received 180 Kg N/fed. as urea or ammonium nitrate. In the second season vitamin-C content was not significantly affected by any of the interaction treatments between N-source and level . Generally, it seems that 120 or 180 Kg N/fed. as urea or ammonium nitrate was the most favorable rate on fruit quality.

The favorable effect of ammonium nitrate application versus urea on TSS % and $NO_3$-N content of fruits may be due to that ammonium nitrate contains 16.5 % $NO_3$-N and plants absorbed more $NO_3^-$ from the ammonium nitrate fertilizer than from urea fertilizer. Adding to that urea should be hydrolyzed first to ammonium and then converted to nitrate through nitrification . i.e. nitrate uptake from ammonium nitrate should be quicker and higher and therefore nitrate accumulation is expected to be higher in plants supplied with ammonium nitrate than urea. These results and its explanation agrees with those of Minotti ( 1975 ); Pill et al ( 1978 ); Ikeda and Osawa (1983) and Magalhaes and Wilcox ( 1984 ).

## 4.2. SECOND EXPERIMENTS :

**Effect of sulphur and phosphorus Fertilization levels on growth, chemical composition, yield and fruit quality of tomato:**

The main effect of sulphur or phosphorus and the interaction effects between these two elements will be discussed under the following characteristics:

4.2.1. Vegetative growth at flowering and fruit setting stages.
4.2.2. Mineral content; N, P, K and S of plant foliage at flowering and fruit setting stages.
4.2.3. Early, marketable, unmarketable and total yield.
4.2.4. Fruit quality; physical and chemical characteristics of tomato fruit.

### 4.2.1.1. Effect of sulphur and / or phosphorus application on vegetative growth of tomato plant at flowering stage.

**a) Effect of sulphur:**

Data in Table ( 17 ) show the effect of elemental sulphur fertilization on vegetative growth of tomato plant Data revealed that plant height, number of leaves and branches per plant were not significantly affected by sulphur application in both seasons. However, fresh weight of leaves and / or branches were increased significantly by increasing level of sulphur application from 0, 150 up to 300 Kg S/fed. in the second season, but variances failed to be significant in the first one. This trend was true in dry weight of leaves and / or branches which increased by S-application than the control with no significant differences between that of plants received 150 or 300 Kg S/fed as shown in the second season.

This increment in plant fresh and dry weights by S-application is in agreement with those reported by Gabal ( 1973 ) using 100 Kg S/fed. and may be due to the acidic effect of S-fertilization on soil-pH. which increased the availability of phosphorus and most micronutrients and consequently plant uptake of these nutrients was increased .

**Table (17): Vegetative growth of tomato plants, at flowering ( 50 days after transplanting ) as affected by sulphur or phosphorus fertilization, during the early summer seasons of 1993 and 1994.**

**Early summer season, 1993**

| Treatments | Plant ht. Cm. | No. of leaves / plant | No. of branche / plant | Fresh weight ( g / plant ) | | | Dry weight ( g / plant ) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | leaves | branches | total | leaves | branches | total |
| **Kg S/fed.** | | | | | | | | | |
| 0 | 37.25 | 20.41 | 2.04 | 19.98 | 6.94 | 26.92 | 3.74 | 1.16 | 4.90 |
| 150 | 35.83 | 23.79 | 2.25 | 21.31 | 7.42 | 28.73 | 3.71 | 1.12 | 4.83 |
| 300 | 37.08 | 20.95 | 1.91 | 19.79 | 7.00 | 26.79 | 3.69 | 1.24 | 4.93 |
| **L.S.D. at 0.05** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** |
| **Kg P2O5/fed.** | | | | | | | | | |
| 0 | 35.38 | 20.88 | 1.83 | 18.14 | 5.87 | 24.01 | 3.27 | 0.96 | 4.23 |
| 32 | 35.61 | 22.55 | 1.94 | 17.98 | 6.25 | 24.23 | 3.41 | 1.14 | 4.55 |
| 64 | 35.83 | 20.22 | 2.00 | 26.06 | 9.49 | 35.55 | 4.63 | 1.47 | 6.10 |
| 96 | 40.05 | 23.22 | 2.50 | 19.25 | 6.87 | 26.12 | 3.55 | 1.12 | 4.67 |
| **L.S.D. at 0.05** | **N.S.** | **N.S** | **0.43** | **5.99** | **2.25** | **6.77** | **0.88** | **N.S.** | **1.02** |

**Early summer season, 1994**

| Treatments | Plant ht. Cm. | No. of leaves / plant | No. of branche / plant | Fresh weight ( g / plant ) | | | Dry weight ( g / plant ) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | leaves | branches | total | leaves | branches | total |
| **Kg S/fed.** | | | | | | | | | |
| 0 | 44.74 | 29.00 | 4.33 | 55.81 | 21.10 | 76.91 | 7.87 | 3.25 | 11.12 |
| 150 | 47.37 | 28.91 | 4.79 | 66.83 | 23.37 | 90.70 | 10.36 | 3.76 | 14.12 |
| 300 | 46.79 | 26.91 | 4.83 | 76.42 | 28.86 | 105.28 | 11.95 | 4.00 | 15.95 |
| **L.S.D. at 0.05** | **N.S.** | **N.S.** | **N.S.** | **10.13** | **2.98** | **9.53** | **2.05** | **0.38** | **2.14** |
| **Kg P2O5/fed.** | | | | | | | | | |
| 0 | 44.05 | 21.50 | 4.11 | 46.86 | 16.40 | 63.26 | 7.19 | 2.75 | 9.94 |
| 32 | 48.05 | 30.16 | 4.77 | 72.44 | 26.86 | 99.30 | 11.93 | 4.04 | 15.97 |
| 64 | 46.21 | 33.38 | 5.00 | 75.52 | 28.50 | 104.04 | 11.42 | 4.08 | 15.50 |
| 96 | 46.88 | 28.05 | 4.72 | 70.59 | 26.67 | 97.26 | 9.99 | 3.80 | 13.79 |
| **L.S.D. at 0.05** | **N.S.** | **4.52** | **N.S.** | **6.41** | **2.92** | **6.84** | **1.06** | **0.59** | **1.24** |

This explanation also in the agreement with Kashirad ( 1972 ); Kashirad and Bazargani ( 1972 ); El - Rawi and Tajuldeen ( 1985 ). Abd El-Fatth et el (1990) also reported that the addition of sulphur to soil caused a decrease in soil pH. Moreover, this result is also in harmony with Yousry et al ( 1984 ) and Heter ( 1985 ), they concluded that the addition of sulphur increased the availability of phosphorus through its effects on soil pH. Moreover, Ryan et al ( 1974 ); Bansol and Singh ( 1975 ) and Babaria and Patel ( 1980 ) reported that sulphur application to calcareous and alkaline soils increased the solubility of many micronutrients; Fe, Mn, Zn and Cu through depressing soil pH and therefore increased plant uptake of these micronutrients.

**b) Effect of phosphorus:**

With respect to phosphorus fertilization, data in Table (17) showed that plant height was not significantly affected by increasing level of P-fertilization in both seasons. However, number of leaves per plant was increased with increasing P-fertilizer within all levels than the control with no significant variances among P-levels from 32 to 64 Kg $P_2O_5$/fed. and then decreased by using 96 Kg $P_2O_5$/fed. as shown in the second season. On the other hand, number of leaves was not significantly affected by P-application levels in the first season. Concerning the number of branches per plant, it was gradually increased with increasing phosphorus application up to 96 Kg $P_2O_5$/fed. as compared with the lower levels. in the first season, but variances failed to reach the level of significance in the second one.

Concerning the fresh weight of leaves and / or branches, results showed that 64 Kg $P_2O_5$/fed. gave the highest plant growth as compared with the other P-levels in the first season. Data of the second season showed the same trend i.e. P-application increased plant growth than the control with no significant variances between 32, 64 or 96 Kg $P_2O_5$/fed.

With respect to dry weight of leaves and / or branches data showed that 64 Kg $P_2O_5$/fed. gave the highest dry weight of leaves and total foliage as compared with the other supplied P-levels or the control, in the first season. Data of the second season showed the same trend and revealed that P-fertilization at 32 or 64 Kg $P_2O_5$/fed. accumulated the highest dry weight with no significant differences between these two treatments. However, heavy application of phosphorus at 96 Kg $P_2O_5$/fed. decreased plant growth expressed as dry weight of leaves and total plant foliage as shown in both seasons. This trend was also true for plant fresh weight in the first season. **It was clear that 64 Kg $P_2O_5$/fed. could be recommended as the best level for tomato plant growth as a general trend for both seasons.**

This increment in tomato plant growth by P-application may be due to the role of phosphorus on root growth, phosphoproteins, phospholipids and ATP & ADP formation ( Atherton and Rudich, 1986 ).

Added to that, the experimental soil reaction is slightly alKaline with pH 8.15 and soil content of available phosphorus is poor ( 0.61 % ). Therefore, increasing P-application may increase the available -P in soil and consequently P-uptake by plants as shown in Table ( 24 ) this result agrees with Tamara ( 1975 ); Bhatangar and pandita ( 1979 ). Whereas, Abdalla et al (1979) found that phosphorus applied as superphosphate fertilizer significantly increased dry weight of leaves and branches of tomato plant. Moreover Fontes ( 1984 ) and Fontes and Wilcox ( 1984 ) reported that P-application at a moderate level increased vegetative growth of tomato plant. but the highest level of phosphorus did not increase tomato plant growth.

**c) Effect of sulphur within phosphorus:**

Concerning the effect of sulphur within phosphorus fertilization on tomato plant growth, data in Table ( 18 ) showed that all the studied growth parameters were not significantly affected by any of the used treatments in the first season except for number of branches per plant when 96 Kg $P_2O_5$ + 150 or 300 Kg S/fed. encouraged branching than the other treatments. In the second season, the same tend was detected for plant height, number of leaves and branches per plant which were not significantly affected by any of the interaction treatments .

With respect to fresh and dry weight of leaves and / or branches, data in Table ( 19 ) showed that the highest values were recorded with application of 32 Kg $P_2O_5$ within 300 Kg S/fed. followed by the application of 64 Kg $P_2O_5$ within 150 or 300 Kg S/fed. and the lowest values were recorded with the control, as shown in the second season. Since no significant variances in fresh and dry weight per plant were detected in the first season.

The interaction data generally showed that S-application at 300 Kg S/fed. within 32 Kg $P_2O_5$/fed. gave the highest plant growth. It is clear that sulphur application at the highest level depressed the optimum level of P-requirements for tomato plant growth. This result may be due to the role of sulphur on acidifing soil reaction which increased the available soil - P and consequently P-uptake as previously discussed under the main effect of sulphur ( 2.1.1.a ) .

**Table (18): Vegetative growth of tomato plants, at flowering stage ( 50 days after transplanting ) as affected by sulphur within phosphorus fertilization during early summer seasons of 1993 and 1994.**

**Early summer season, 1993**

| Treatments | | Plant ht. | No. of leaves | No. of branches | Fresh weight ( g / plant ) | | | Dry weight ( g / plant ) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Kg S/fed. | Kg P2O5/fed. | Cm. | / plant | / plant | leaves | branches | total | leaves | branches | total |
| 0 | 0 | 37.00 | 19.00 | 1.83 | 15.88 | 6.07 | 21.95 | 3.14 | 0.92 | 4.06 |
| | 32 | 36.33 | 26.66 | 2.33 | 19.34 | 6.01 | 25.35 | 3.60 | 1.12 | 4.72 |
| | 64 | 37.00 | 17.33 | 2.16 | 27.36 | 9.69 | 37.05 | 4.94 | 1.48 | 6.42 |
| | 96 | 38.66 | 18.66 | 1.83 | 17.35 | 5.99 | 23.34 | 3.30 | 1.12 | 4.42 |
| 150 | 0 | 33.83 | 22.66 | 2.00 | 20.29 | 5.39 | 25.68 | 3.18 | 0.78 | 3.96 |
| | 32 | 34.66 | 20.83 | 2.00 | 16.87 | 6.71 | 23.58 | 3.26 | 1.14 | 4.40 |
| | 64 | 34.50 | 22.16 | 1.83 | 28.73 | 10.52 | 39.25 | 4.95 | 1.55 | 6.50 |
| | 96 | 40.33 | 29.50 | 3.16 | 19.35 | 7.08 | 26.43 | 3.46 | 1.03 | 4.49 |
| 300 | 0 | 35.33 | 21.00 | 1.66 | 18.27 | 6.15 | 24.42 | 3.50 | 1.20 | 4.70 |
| | 32 | 35.83 | 20.16 | 1.50 | 17.74 | 6.03 | 23.77 | 3.36 | 1.16 | 4.52 |
| | 64 | 36.00 | 21.16 | 2.00 | 22.10 | 8.27 | 30.37 | 4.00 | 1.38 | 5.38 |
| | 96 | 41.16 | 21.50 | 2.50 | 21.06 | 7.54 | 28.60 | 3.90 | 1.22 | 5.12 |
| **L.S.D. at 0.05** | | **N.S.** | **N.S.** | **0.74** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** |

**Early summer season, 1994**

| Treatments | | Plant ht. | No. of leaves | No. of branches | Fresh weight ( g / plant ) | | | Dry weight ( g / plant ) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Kg S/fed. | Kg P2O5/fed. | Cm. | / plant | / plant | leaves | branches | total | leaves | branches | total |
| 0 | 0 | 40.50 | 21.66 | 3.66 | 29.29 | 10.99 | 20.28 | 4.47 | 2.38 | 6.85 |
| | 32 | 44.66 | 30.50 | 4.50 | 58.01 | 20.99 | 79.00 | 8.07 | 3.30 | 11.37 |
| | 64 | 47.63 | 34.16 | 5.00 | 74.65 | 26.93 | 101.58 | 10.44 | 3.80 | 14.24 |
| | 96 | 46.16 | 29.66 | 4.16 | 61.29 | 25.47 | 86.76 | 8.48 | 3.51 | 11.99 |
| 150 | 0 | 46.83 | 19.83 | 4.83 | 50.81 | 18.97 | 69.78 | 7.67 | 3.21 | 10.88 |
| | 32 | 50.83 | 27.50 | 4.83 | 60.99 | 21.77 | 82.76 | 9.59 | 3.66 | 13.25 |
| | 64 | 47.00 | 38.33 | 4.50 | 78.75 | 29.34 | 108.09 | 13.18 | 4.20 | 17.38 |
| | 96 | 44.83 | 30.00 | 5.00 | 76.78 | 25.42 | 102.20 | 11.01 | 3.96 | 14.97 |
| 300 | 0 | 44.83 | 23.00 | 3.83 | 60.47 | 19.24 | 79.71 | 9.43 | 2.67 | 12.10 |
| | 32 | 48.66 | 32.50 | 5.00 | 98.34 | 37.84 | 136.18 | 17.23 | 5.16 | 22.39 |
| | 64 | 44.00 | 27.66 | 5.50 | 73.18 | 29.23 | 102.41 | 10.66 | 4.24 | 14.90 |
| | 96 | 49.66 | 24.50 | 5.00 | 73.71 | 29.14 | 102.85 | 10.50 | 3.94 | 14.44 |
| **L.S.D. at 0.05** | | **N.S.** | **N.S.** | **N.S.** | **11.11** | **5.06** | **11.85** | **1.85** | **N.S.** | **2.16** |

### 4.2.1.2. Effect of sulphur and / or phosphorus fertilization level on vegetative growth of tomato plant at fruit setting stage.

**a) Effect of sulphur:**

Data of the second plant sample at fruit set stage, ( Table, 19 ) showed that plant height, number of leaves and branches per plant were not significantly affect by S-application level in both seasons except for plant height in the second season when increased with increasing sulphur application from 0 up to 150 Kg S/fed. and then decreased by adding 300 Kg S/fed. With respect to fresh and dry weights of leaves and / or branches per plant data in Table ( 20 ) showed that they were increased gradually and significantly with increasing S-application from 0, 150 up to 300 Kg S/fed in the second season . Results of fresh and dry weights per plant were not significant in the first season except for total dry weight per plant which increased byS-application at 150 or 300 Kg S/fed as compared with control.

This increment in plant growth by S-application may be due to the role of sulphur on reducing soil-pH and increasing availability of phosphorus and most micronutrients . This result agrees with Kashirad ( 1972 ); El-Rawi and Tajuldeen ( 1985 ) and Abd El-Fatth et al ( 1990 ). Moreover, Heter (1985) reported that the addition of sulphur increased the availability of phosphorus through its effect on soil pH. Babaria and Potel ( 1980 ) reported that sulphur application to calcareous and alkaline soils increased the solubility of some micronutrients ( Fe, Mn. Zn and Cu ) through lowering soil - pH and therefore increased plant uptake of these nutrients.

**Table (19): Vegetative growth of tomato plants, at fruit set stage ( 70 days after transplanting ) as affected by sulphur or phosphorus fertilization, during early summer season of 1993 and 1994.**

**Early summer season, 1993**

| Treatments | Plant ht Cm. | No. of leaves / plant | No. of branches / plant | Fresh weight ( g / plant ) leaves | branches | total | Dry weight ( g / plant ) leaves | branches | total |
|---|---|---|---|---|---|---|---|---|---|
| **Kg S/fed.** | | | | | | | | | |
| 0 | 52.37 | 45.22 | 6.08 | 107.82 | 42.20 | 150.02 | 19.37 | 6.02 | 25.39 |
| 150 | 57.96 | 44.25 | 6.20 | 120.53 | 53.26 | 173.79 | 20.32 | 8.24 | 28.56 |
| 300 | 54.71 | 47.49 | 6.62 | 114.62 | 46.71 | 163.33 | 19.92 | 8.29 | 28.21 |
| **L.S.D. at 0.05** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **2.01** |
| **Kg P2O5/fed.** | | | | | | | | | |
| 0 | 54.31 | 41.14 | 6.11 | 99.09 | 40.47 | 139.56 | 15.71 | 5.90 | 21.61 |
| 32 | 57.00 | 45.72 | 6.11 | 111.77 | 50.94 | 162.71 | 18.57 | 6.75 | 25.32 |
| 64 | 54.48 | 45.05 | 7.00 | 137.40 | 58.83 | 196.23 | 25.28 | 11.05 | 36.33 |
| 96 | 54.27 | 50.71 | 6.11 | 109.03 | 41.97 | 151.00 | 19.92 | 6.37 | 26.29 |
| **L.S.D. at 0.05** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **4.48** | **2.74** | **5.04** |

**Early summer season, 1994**

| Treatments | Plant ht Cm. | No. of leaves / plant | No. of branches / plant | Fresh weight ( g / plant ) leaves | branches | total | Dry weight ( g / plant ) leaves | branches | total |
|---|---|---|---|---|---|---|---|---|---|
| **Kg S/fed.** | | | | | | | | | |
| 0 | 62.59 | 66.47 | 6.70 | 310.64 | 127.88 | 438.52 | 41.88 | 17.25 | 59.13 |
| 150 | 77.05 | 55.21 | 6.79 | 366.55 | 176.15 | 542.70 | 52.58 | 25.54 | 78.12 |
| 300 | 68.99 | 60.45 | 6.50 | 424.05 | 173.39 | 597.44 | 62.82 | 27.44 | 90.26 |
| **L.S.D. at 0.05** | **6.98** | **N.S.** | **N.S.** | **20.39** | **8.64** | **20.35** | **9.43** | **1.85** | **9.37** |
| **Kg P2O5/fed.** | | | | | | | | | |
| 0 | 67.49 | 42.36 | 5.90 | 252.50 | 104.92 | 357.42 | 30.98 | 16.20 | 47.18 |
| 32 | 77.06 | 61.99 | 7.13 | 417.57 | 168.80 | 586.37 | 62.00 | 25.35 | 87.35 |
| 64 | 70.18 | 74.86 | 7.07 | 408.41 | 184.88 | 593.29 | 62.96 | 28.01 | 90.97 |
| 96 | 63.44 | 63.63 | 6.55 | 389.84 | 177.95 | 567.79 | 53.77 | 25.42 | 79.19 |
| **L.S.D. at 0.05** | **5.97** | **10.80** | **N.S.** | **30.93** | **17.09** | **37.93** | **7.24** | **3.69** | **8.79** |

**b) Effect of phosphorus:**

Concerning the effect of phosphorus fertilization on tomato plant growth at fruit set stage, data in Table ( 19 ) showed that plant height, number of leaves or branches, fresh weight of leaves and / or branches were not significantly affected due to level of P-application in the first season. However in the second season results showed that 32 Kg $P_2O_5$/fed. had the most favorable effect on all the studied characteristics of plant growth According to fresh and dry weight, adding phosphorus within all levels increased plant growth than the control as shown in the second season. Results of the first season showed that 64 Kg $P_2O_5$/fed. gave the best results of plant dry weight. Whereas, phosphorus application at 32 and 64 Kg $P_2O_5$/fed. gave similar fresh and dry weights and higher than the control as shown in the second season, However, the highest P-application 96 Kg $P_2O_5$/fed. decreased plant dry weight as a general trend for both seasons as compared with the moderate levels of 32 or 64 Kg $P_2O_5$/fed. This increment in plant growth by P-application may be due to the role of phosphorus on root development, phosphoproteins, phospholipids and ATP & ADP formation ( Atherton and Rudich; 1986 ). These results agree with Tamara ( 1975 ); Bhatangar and Pandita ( 1979 ) and Abdalla et al ( 1979 ) who found that P-applied as superphosphate fertilizer significantly increased dry weight of leaves and branches of tomato plant. Moreover, Fontes ( 1984 ), Fontes and Wilcox ( 1984 ) reported that phosphorus application at a moderate level increased vegetative growth of tomato plant. but the highest level of phosphorus did not affect plant growth .

**c) Effect of sulphur within phosphorus:**

With respect to the effect of sulphur within phosphorus fertilization on tomato plant growth, data in Table ( 20 ) showed that all the studied growth parameters were not significantly affected by sulphur within phosphorus application treatment in the first season. Data of the second season

**Table (20): Vegetative growth of tomato plants, at fruit set stage ( 70 days after transplanting ) as affected by sulphur within phosphorus fertilization, during early summer season, 1993 and 1994.**

**Early summer season, 1993**

| Treatments | | Plant ht. | No. of leaves | No. of branches | Fresh weight ( g / plant ) | | | Dry weight ( g / plant ) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Kg S/fed. | Kg P2O5/fed. | Cm. | / plant | / plant | leaves | branche | total | leaves | branches | total |
| 0 | 0 | 55.73 | 33.26 | 5.66 | 68.38 | 40.95 | 109.33 | 12.59 | 6.20 | 18.79 |
| | 32 | 51.80 | 50.56 | 6.00 | 111.07 | 49.08 | 161.07 | 20.08 | 6.02 | 26.10 |
| | 64 | 50.76 | 44.33 | 6.50 | 130.25 | 47.56 | 177.81 | 22.86 | 7.01 | 29.87 |
| | 96 | 51.20 | 52.73 | 6.16 | 120.67 | 31.20 | 151.87 | 21.97 | 4.83 | 26.80 |
| 150 | 0 | 54.43 | 41.66 | 6.33 | 116.20 | 43.16 | 159.36 | 19.21 | 5.64 | 24.85 |
| | 32 | 60.10 | 39.53 | 5.83 | 109.90 | 45.60 | 155.50 | 19.11 | 6.00 | 25.11 |
| | 64 | 57.06 | 48.83 | 6.66 | 145.02 | 74.05 | 219.07 | 22.48 | 13.07 | 35.55 |
| | 96 | 60.26 | 47.00 | 6.00 | 111.00 | 50.22 | 161.22 | 20.47 | 8.25 | 28.72 |
| 300 | 0 | 52.76 | 48.50 | 6.33 | 112.71 | 37.30 | 150.01 | 15.33 | 5.87 | 21.20 |
| | 32 | 59.10 | 47.06 | 6.16 | 113.42 | 58.16 | 171.58 | 16.54 | 8.21 | 24.75 |
| | 64 | 55.63 | 42.00 | 7.83 | 136.92 | 54.88 | 191.80 | 30.50 | 13.06 | 43.56 |
| | 96 | 51.36 | 52.40 | 6.16 | 95.42 | 44.49 | 139.91 | 17.32 | 6.02 | 23.34 |
| L.S.D. at 0.05 | | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. |

**Early summer season, 1994**

| Treatments | | Plant ht. | No. of leaves | No. of branches | Fresh weight ( g / plant ) | | | Dry weight ( g / plant ) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Kg S/fed. | Kg P2O5/fed. | Cm. | / plant | / plant | leaves | branche | total | leaves | branches | total |
| 0 | 0 | 60.75 | 37.91 | 6.16 | 125.97 | 74.86 | 200.83 | 17.90 | 12.95 | 30.85 |
| | 32 | 63.42 | 57.73 | 7.46 | 335.29 | 106.24 | 441.53 | 44.98 | 13.40 | 58.38 |
| | 64 | 65.25 | 86.57 | 6.83 | 355.33 | 138.43 | 493.76 | 48.26 | 20.02 | 68.28 |
| | 96 | 60.94 | 83.66 | 6.33 | 425.98 | 192.02 | 618.00 | 56.39 | 22.64 | 79.03 |
| 150 | 0 | 74.93 | 36.29 | 6.00 | 290.62 | 115.56 | 406.18 | 36.36 | 17.55 | 53.91 |
| | 32 | 87.94 | 52.52 | 6.93 | 389.04 | 184.16 | 573.20 | 56.23 | 28.16 | 84.39 |
| | 64 | 77.55 | 84.33 | 7.06 | 396.93 | 219.51 | 616.44 | 59.40 | 30.41 | 89.81 |
| | 96 | 67.80 | 47.70 | 7.16 | 389.63 | 185.36 | 574.99 | 58.34 | 30.05 | 88.39 |
| 300 | 0 | 66.80 | 52.90 | 5.53 | 340.92 | 124.34 | 465.26 | 38.69 | 18.09 | 56.78 |
| | 32 | 79.81 | 75.72 | 7.00 | 528.38 | 216.01 | 744.39 | 84.78 | 34.48 | 119.26 |
| | 64 | 67.76 | 53.67 | 7.33 | 472.97 | 196.72 | 669.69 | 81.22 | 33.60 | 114.82 |
| | 96 | 61.58 | 50.53 | 6.16 | 353.93 | 156.47 | 510.40 | 46.59 | 23.58 | 70.17 |
| L.S.D. at 0.05 | | N.S. | 18.88 | N.S. | 53.58 | 29.60 | 65.70 | 12.55 | 6.40 | 15.22 |

Table (20)

showed the same trend only for plant height and number of branches per plant, However, number of leaves per plant gave the highest values with 64 or 96 Kg $P_2O_5$/fed. without sulphur application, 64 Kg $P_2O_5$ + 150 Kg S/fed. and 32 Kg $P_2O_5$ + 300 Kg S/fed. But the lowest number of leaves was found in the control, as shown in the second season. Concerning the fresh and dry weights of leaves and / or branches, data of the second season also showed a significant effect of sulphur within phosphorus treatments. The highest values of fresh and dry weight per plant were recorded with 32 or 64 Kg $P_2O_5$ + 300 Kg S/fed. followed by 150 Kg S/fed. within all P-levels followed by 96 Kg $P_2O_5$/fed. without S-application, and the lowest value were recorded with the control which received 0 P or S. ***It was clear that S-application at high or moderate levels 150 or 300 Kg S/fed. could save P-application and reduce the applied level of p-required to get the same effect on plant growth.*** These results may be due to that sulphur application especially at medium or high levels ( 150 or 300 Kg S/fed. ) resulted a reduction in soil-pH which increesed avilability of phosphours and some micronutrient and consequently increased plant uptake of these nutrients as mentioned by Kashirad ( 1972 ); El-Rawi and Tajuldeen ( 1985 ) and Yousry et al, 1984 and some micronutrient ( Ryan et al , 1974; Babaria and Patel, 1980 and Abd El-Fatth & Hilal, 1985 ) . In addition to the favorable effect of P-application on plant growth. Have been mentioned by Tamara ( 1975 ), Abdalla et al ( 1979 ); Fontes ( 1984 ) and Fontes and Wilcox ( 1984 ) on tomato. These results indicate that each of the two factors act with each other in increasing the vegetative growth of tomato plant.

### 4.2.2. Mineral content of tomato plant foliage:

### 4.2.2.1 Effect of sulphur application on mineral content of tomato plant foliage at flowering stage.

Data showed that N, K and S % in leaves or branches were not significantly affected by sulphur application in both seasons ( Table, 21 and Fig. 4 ). However, P % was gradually and significantly increased by increasing level of sulphur application from 0, 150 up to 300 Kg S/fed. in both seasons. This increment of P % due to sulphur application may be referred to the acidic effect of sulphur on soil pH, which increased the availability of phosphorus as mentioned by Kashirad ( 1972 ); Kashirad and Bazargani ( 1972 ) and El-Rawi and Tajuldeen ( 1985 ). Moreover, Abd El-Fattah et al ( 1990 ) found that the addition of sulphur to soils decreased soil pH, the rate of decreasing was increased with increasing sulphur application. Moreover, Heter ( 1985 ) indicated that most of the added phosphorus to calcareous soil will be fixed as an unavailable form for plant uptake, the addition of sulphur expected to increase the availability of phosphorus by increasing the solubility of Ca-phosphat compounds especially under such soil conditions of this experiment with pH 8.15. The insignificant effect of S-application on N, K and S % may be due to that the first season of 1993 was colder than 1994 (Table, B) therefore, the response of mineral uptake was more clear in the second season only as shown in Table ( 22 ), added to that all plots received a standard levels of N and K fertilizers ( 120 Kg N + 48 Kg $K_2O$/fed. ).

Concerning N, P, K and S uptake, data in Table ( 22 ) showed that N, K and S uptake of leaves and / or branches were increased with increasing level of sulphur application from 0 up to 150 Kg S/fed. with no significant differences between 150 or 300 Kg S/fed. Whereas, P-uptake in leaves and / or branches was gradually and significantly increased by increasing level of S-application from 0, 150 up to 300 Kg S/fed as shown in the second season.

Table (21): N, P, K and S percentage of tomato plant foliage at flowering stage ( 50 days after transplanting ) as affected by sulphur or phosphorus fertilization, during the seasons of 1993 and 1994.

**Early summer season, 1993**

| Treatments | Leaves | | | | Branches | | | |
|---|---|---|---|---|---|---|---|---|
| | N % | P % | K % | S % | N % | P % | K % | S % |
| **Kg S/fed.** | | | | | | | | |
| 0 | 4.54 | 0.45 | 4.25 | 0.74 | 2.45 | 0.35 | 3.20 | 0.67 |
| 150 | 4.29 | 0.47 | 4.24 | 0.75 | 2.49 | 0.36 | 3.22 | 0.67 |
| 300 | 4.24 | 0.49 | 4.22 | 0.74 | 2.58 | 0.37 | 3.30 | 0.67 |
| **L.S.D. at 0.05** | **N.S.** | **0.01** | **N.S.** | **N.S.** | **N.S.** | **0.01** | **N.S.** | **N.S.** |
| **Kg P2O5/fed.** | | | | | | | | |
| 0 | 4.27 | 0.42 | 4.15 | 0.72 | 2.21 | 0.33 | 3.19 | 0.66 |
| 32 | 4.44 | 0.47 | 4.23 | 0.74 | 2.61 | 0.36 | 3.27 | 0.67 |
| 64 | 4.49 | 0.49 | 4.31 | 0.75 | 2.49 | 0.37 | 3.28 | 0.69 |
| 96 | 4.33 | 0.51 | 4.25 | 0.77 | 2.71 | 0.39 | 3.22 | 0.67 |
| **L.S.D. at 0.05** | **N.S.** | **0.02** | **N.S.** | **N.S.** | **N.S.** | **0.01** | **N.S.** | **N.S.** |

**Early summer season, 1994**

| Treatments | Leaves | | | | Branches | | | |
|---|---|---|---|---|---|---|---|---|
| | N % | P % | K % | S % | N % | P % | K % | S % |
| **Kg S/fed.** | | | | | | | | |
| 0 | 4.23 | 0.45 | 4.57 | 0.75 | 2.44 | 0.35 | 3.46 | 0.67 |
| 150 | 4.19 | 0.47 | 4.66 | 0.74 | 2.45 | 0.37 | 3.48 | 0.67 |
| 300 | 4.13 | 0.50 | 4.62 | 0.74 | 2.41 | 0.40 | 3.52 | 0.68 |
| **L.S.D. at 0.05** | **N.S.** | **0.01** | **N.S.** | **N.S.** | **N.S.** | **0.02** | **N.S.** | **N.S.** |
| Kg P2O5/fed. | | | | | | | | |
| 0 | 4.07 | 0.44 | 4.44 | 0.73 | 2.29 | 0.34 | 3.31 | 0.66 |
| 32 | 4.19 | 0.46 | 4.64 | 0.75 | 2.47 | 0.37 | 3.54 | 0.68 |
| 64 | 4.27 | 0.48 | 4.68 | 0.75 | 2.48 | 0.38 | 3.55 | 0.68 |
| 96 | 4.20 | 0.51 | 4.71 | 0.74 | 2.49 | 0.41 | 3.55 | 0.67 |
| **L.S.D. at 0.05** | **N.S.** | **0.01** | **0.15** | **N.S.** | **N.S.** | **0.01** | **0.16** | **0.01** |

**Table (22): N, P, K and S uptake of tomato plant foliage at flowering stage ( 50 days after transplanting ) as affected by sulphur or phosphorus fertilization, during the seasons of 1993 and 1994.**

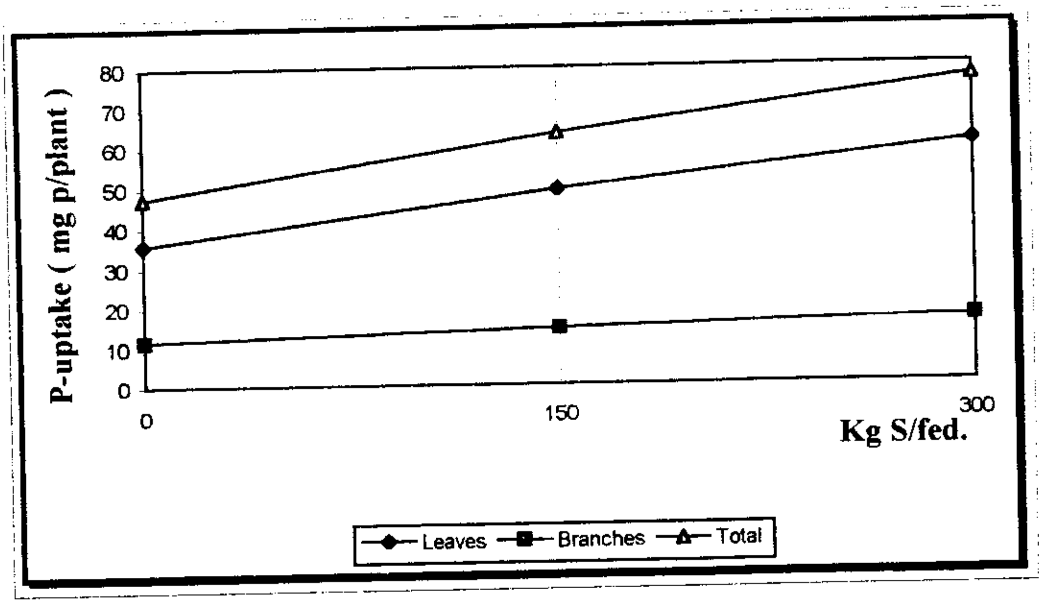
**Element uptake at early summer season, 1993**

| Treatments | Leaves ( mg/plant ) | | | | Branches ( mg/plant ) | | | | Total ( mg/plant ) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | P | K | S | N | P | K | S | N | P | K | S |
| **Kg S/fed.** | | | | | | | | | | | | |
| 0 | 170.70 | 17.10 | 159.50 | 25.70 | 28.50 | 4.10 | 37.30 | 7.80 | 199.20 | 21.20 | 196.80 | 33.50 |
| 150 | 158.10 | 17.80 | 157.90 | 28.30 | 29.80 | 4.00 | 36.20 | 7.60 | 187.90 | 21.80 | 194.10 | 35.90 |
| 300 | 157.20 | 18.40 | 156.20 | 27.60 | 32.00 | 4.60 | 40.90 | 8.30 | 189.20 | 23.00 | 197.10 | 35.90 |
| **L.S.D. at 0.05** | **N.S** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** |
| **Kg P2O5/fed.** | | | | | | | | | | | | |
| 0 | 137.40 | 13.90 | 135.60 | 23.90 | 22.10 | 3.10 | 30.90 | 6.30 | 159.50 | 17.00 | 166.50 | 30.20 |
| 32 | 152.20 | 16.00 | 144.30 | 25.50 | 29.30 | 4.00 | 37.70 | 7.60 | 181.50 | 20.00 | 182.00 | 33.10 |
| 64 | 209.50 | 22.90 | 199.90 | 32.30 | 36.60 | 5.40 | 47.70 | 10.10 | 246.10 | 28.30 | 247.60 | 42.40 |
| 96 | 148.80 | 18.30 | 151.70 | 27.30 | 32.50 | 4.30 | 36.30 | 7.50 | 181.30 | 22.60 | 188.00 | 34.80 |
| **L.S.D. at 0.05** | **40.50** | **4.50** | **37.50** | **N.S.** | **N.S.** | **1.40** | **N.S.** | **N.S.** | **41.10** | **4.90** | **41.00** | **7.00** |

**Element uptake at early summer season, 1994**

| Treatments | Leaves ( mg/plant ) | | | | Branches ( mg/plant ) | | | | Total ( mg/plant ) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | P | K | S | N | P | K | S | N | P | K | S |
| **Kg S/fed.** | | | | | | | | | | | | |
| 0 | 332.50 | 35.70 | 361.90 | 59.40 | 80.60 | 11.60 | 113.10 | 21.80 | 413.10 | 47.30 | 475.00 | 81.20 |
| 150 | 437.00 | 49.20 | 486.00 | 77.20 | 91.60 | 14.20 | 130.80 | 25.30 | 528.60 | 63.40 | 616.80 | 102.50 |
| 300 | 496.90 | 60.50 | 553.90 | 89.40 | 97.10 | 16.30 | 142.00 | 27.30 | 594.00 | 76.80 | 695.90 | 116.70 |
| **L.S.D. at 0.05** | **105.80** | **10.90** | **106.40** | **14.00** | **11.70** | **0.90** | **11.20** | **2.70** | **100.80** | **11.30** | **107.70** | **15.00** |
| **Kg P2O5/fed.** | | | | | | | | | | | | |
| 0 | 291.10 | 32.20 | 319.80 | 55.90 | 63.40 | 9.40 | 91.50 | 18.30 | 354.50 | 41.60 | 411.30 | 74.20 |
| 32 | 490.70 | 55.00 | 540.60 | 87.80 | 98.90 | 15.10 | 143.30 | 27.50 | 589.60 | 70.10 | 683.90 | 115.30 |
| 64 | 487.70 | 55.60 | 536.70 | 86.30 | 101.70 | 15.90 | 145.10 | 27.90 | 589.40 | 71.50 | 681.80 | 114.20 |
| 96 | 419.20 | 51.10 | 472.00 | 74.30 | 95.00 | 15.70 | 134.80 | 25.50 | 514.20 | 66.80 | 606.80 | 99.80 |
| **L.S.D. at 0.05** | **46.20** | **5.40** | **51.00** | **7.70** | **17.40** | **2.30** | **21.00** | **3.90** | **49.60** | **6.20** | **56.50** | **8.80** |

Fig ( 4 ): Phosphorus uptake ( mg p/plant ) of tomato plant foliage as affected by elemental sulphur application, at flowering stage.



Although the same trend was found in the first season but variances failed to reach the level of significance.

This increment in N, P, K and S uptake may be due to the improved vegetative growth of tomato plant as a result of S-application which consequently increased minerals availability and its uptake. The increase in P-uptake and its percentage in tomato plant foliage as a result of S-application could be referred to the effect of sulphur on the availability of soil-phosphorus under our field experiment of soil pH ( 8.15 ). This explanation a grees with those of Vol Nikov et al (1973); Yousry et al ( 1984 ) and Heter (1985).

### 4.2.2.2. Effect of phosphorus application on mineral content of tomato plant foliage at flowering stage.

Data in Table ( 21 ) showed that P % in leaves and branches was gradually and significantly increased with increasing P-application from 0, 32, 64 up to 96 Kg $P_2O_5$/fed. in both seasons. K % in leaves and branches and S % in branches were increased with increasing level of P-application from 0 to 32 Kg $P_2O_5$/fed. with no significant deference's between 32, 64 and 96 Kg $P_2O_5$/fed. in the second season, but variances in K and S % due to P-application failed to reach the level of significance in the first season. Moreover S % and N % of leaves as well as N% in branches were not significantly affected by P-application in both seasons.

This increment of P % in tomato plant foliage may be due to the increase in the availability of P and its uptake by tomato plant as a result of increasing P-application. The theory of anion, cation balance as mentioned by Kirkby and Mengel ( 1967 ) may explain the increase in $K^+$ uptake as a result increasing $HPO_4^{--}$ uptake.

Concerning the mineral uptake, data in Table ( 22 ) showed that N, P, K and S uptake were significantly increased with increasing levels of P-application from 0 up to 32 Kg $P_2O_5$/fed. in the second season or up to 64 Kg $P_2O_5$/fed. in the first season and then decreased by increasing P-application at 96 Kg $P_2O_5$ /fed. This trend was true except for S-uptake in leaves; N, K and S uptake in branches which were not significantly affected by increasing level of P-fertilizer as shown in the first season.

This increment in minerals uptake may be due to the increase in tomato plant growth as a result of P-application which consequently increased the uptake of other minerals uptake such N, P, K and S.

### 4.2.2.3. Effect of sulphur within phosphorus application on mineral content of tomato plant foliage at flowerings stage.

Data in Table ( 23 ) showed that N, P, K and S % in leaves or branches at flowering stage were not significantly affected by the interaction treatment between sulphur and phosphorus in both seasons.

Concerning the mineral uptake, date in Table ( 24 ) also showed that N, P, K and S uptake in leaves, branches and total plant foliage were not significantly affected by sulphur within phospharus appellation treatments in the first season. In the second season minerals uptake of branches also was not significantly affected by this interaction treatments, except N, P, K and S uptake of plant foliage or leaves; it showed an opposite trend i.e. 32 Kg $P_2O_5$/fed. + 300 Kg S/fed. followed by 64 Kg $P_2O_5$/fed + 150 Kg S/fed.; it gave the highest uptake and the lowest value were recorded in the control.

As a general trend N, P, K and S accumulation were higher in leaves as compared with branches at flowering stage.

**Table (23): N, P, K and S concentration of tomato plant foliage at flowering stage ( 50 days after transplanting ) as affected by sulphur within phosphorus fertilization, during the seasons of 1993 and 1994.**

**Early summer season, 1993**

| Treatments | | Leaves | | | | Branches | | | |
|---|---|---|---|---|---|---|---|---|---|
| Kg S/fed. | Kg P2O5/fed. | N % | P % | K % | S % | N % | P % | K % | S % |
| 0 | 0 | 4.50 | 0.41 | 4.10 | 0.71 | 2.16 | 0.32 | 3.23 | 0.68 |
| | 32 | 4.50 | 0.45 | 4.16 | 0.76 | 2.50 | 0.34 | 3.20 | 0.67 |
| | 64 | 4.66 | 0.46 | 4.33 | 0.74 | 2.33 | 0.38 | 3.26 | 0.67 |
| | 96 | 4.50 | 0.49 | 4.43 | 0.77 | 2.83 | 0.38 | 3.13 | 0.66 |
| 150 | 0 | 3.83 | 0.42 | 4.20 | 0.74 | 2.16 | 0.33 | 3.16 | 0.65 |
| | 32 | 4.50 | 0.47 | 4.30 | 0.75 | 2.83 | 0.37 | 3.26 | 0.66 |
| | 64 | 4.33 | 0.50 | 4.36 | 0.77 | 2.33 | 0.37 | 3.23 | 0.71 |
| | 96 | 4.50 | 0.51 | 4.10 | 0.76 | 2.66 | 0.38 | 3.23 | 0.68 |
| 300 | 0 | 4.50 | 0.44 | 4.16 | 0.72 | 2.33 | 0.34 | 3.20 | 0.66 |
| | 32 | 4.33 | 0.49 | 4.23 | 0.73 | 2.50 | 0.37 | 3.36 | 0.68 |
| | 64 | 4.50 | 0.52 | 4.26 | 0.76 | 2.83 | 0.38 | 3.36 | 0.69 |
| | 96 | 3.66 | 0.54 | 4.23 | 0.78 | 2.66 | 0.41 | 3.30 | 0.67 |
| L.S.D. at 0.05 | | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. |

**Early summer season, 1994**

| Treatments | | Leaves | | | | Branches | | | |
|---|---|---|---|---|---|---|---|---|---|
| Kg S/fed. | Kg P2O5/fed. | N % | P % | K % | S % | N % | P % | K % | S % |
| 0 | 0 | 4.16 | 0.43 | 4.43 | 0.74 | 2.16 | 0.32 | 3.36 | 0.66 |
| | 32 | 4.00 | 0.44 | 4.56 | 0.74 | 2.46 | 0.34 | 3.43 | 0.68 |
| | 64 | 4.26 | 0.46 | 4.63 | 0.76 | 2.53 | 0.36 | 3.50 | 0.67 |
| | 96 | 4.50 | 0.47 | 4.66 | 0.76 | 2.63 | 0.39 | 3.56 | 0.67 |
| 150 | 0 | 4.00 | 0.44 | 4.43 | 0.73 | 2.43 | 0.34 | 3.23 | 0.66 |
| | 32 | 4.36 | 0.46 | 4.66 | 0.75 | 2.63 | 0.37 | 3.63 | 0.68 |
| | 64 | 4.26 | 0.48 | 4.76 | 0.76 | 2.23 | 0.39 | 3.63 | 0.68 |
| | 96 | 4.16 | 0.50 | 4.80 | 0.73 | 2.53 | 0.40 | 3.43 | 0.67 |
| 300 | 0 | 4.06 | 0.46 | 4.46 | 0.74 | 2.30 | 0.36 | 3.36 | 0.67 |
| | 32 | 4.23 | 0.49 | 4.70 | 0.76 | 2.33 | 0.40 | 3.56 | 0.68 |
| | 64 | 4.30 | 0.52 | 4.66 | 0.74 | 2.70 | 0.41 | 3.53 | 0.69 |
| | 96 | 3.96 | 0.55 | 4.66 | 0.74 | 2.33 | 0.44 | 3.66 | 0.67 |
| L.S.D. at 0.05 | | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. |

**Table (24): N, P, K and S uptake of tomato plant foliage at flowering stage ( 50 days after transplanting ) as affected by sulfur within phosphorus fertilization, during the seasons of 1993 and 1994.**

**Early summer season, 1993**

| Treatments | | Leaves ( mg/plant ) | | | | Branches ( mg/plant ) | | | | Total ( mg/plant ) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kg S/fed. | Kg P2O5/fed. | N | P | K | S | N | P | K | S | N | P | K | S |
| 0 | 0 | 139.30 | 12.80 | 128.20 | 22.10 | 20.30 | 2.90 | 29.70 | 6.30 | 159.60 | 15.70 | 157.90 | 28.40 |
| | 32 | 162.30 | 16.30 | 150.10 | 27.50 | 26.80 | 3.80 | 36.40 | 7.60 | 189.10 | 20.10 | 186.50 | 35.10 |
| | 64 | 236.10 | 23.20 | 213.00 | 28.00 | 35.20 | 5.50 | 48.00 | 10.00 | 271.30 | 28.70 | 261.00 | 38.00 |
| | 96 | 145.10 | 16.10 | 146.80 | 25.30 | 31.90 | 4.20 | 35.20 | 7.40 | 177.00 | 20.30 | 182.00 | 32.70 |
| 150 | 0 | 116.70 | 13.60 | 133.20 | 23.80 | 17.00 | 2.50 | 24.60 | 5.00 | 133.70 | 16.10 | 157.80 | 28.80 |
| | 32 | 148.40 | 15.30 | 140.60 | 24.60 | 32.60 | 4.20 | 38.10 | 7.50 | 181.00 | 19.50 | 178.70 | 32.10 |
| | 64 | 213.00 | 24.80 | 216.00 | 38.40 | 36.00 | 5.70 | 49.20 | 11.00 | 249.00 | 30.50 | 265.20 | 49.40 |
| | 96 | 154.40 | 17.70 | 142.10 | 26.60 | 33.70 | 3.90 | 33.10 | 7.00 | 188.10 | 21.60 | 175.20 | 33.60 |
| 300 | 0 | 156.30 | 15.40 | 145.50 | 25.80 | 29.00 | 4.00 | 38.50 | 7.80 | 185.30 | 19.40 | 184.00 | 33.60 |
| | 32 | 146.10 | 16.40 | 142.40 | 24.40 | 28.60 | 4.20 | 38.60 | 7.90 | 174.70 | 20.60 | 181.00 | 32.30 |
| | 64 | 179.60 | 20.90 | 170.70 | 30.50 | 38.60 | 5.20 | 46.10 | 9.30 | 218.20 | 26.10 | 216.80 | 39.80 |
| | 96 | 147.10 | 21.10 | 166.40 | 29.80 | 32.10 | 5.00 | 40.70 | 8.20 | 179.20 | 26.10 | 207.10 | 38.00 |
| **L.S.D. at 0.05** | | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** |

**Early summer season, 1994**

| Treatments | | Leaves ( mg/plant ) | | | | Branches ( mg/plant ) | | | | Total ( mg/plant ) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kg S/fed. | Kg P2O5/fed. | N | P | K | S | N | P | K | S | N | P | K | S |
| 0 | 0 | 185.60 | 19.10 | 198.30 | 33.10 | 52.10 | 7.70 | 80.50 | 15.90 | 237.70 | 26.80 | 278.80 | 49.00 |
| | 32 | 322.60 | 35.80 | 368.80 | 60.20 | 80.80 | 11.30 | 113.90 | 22.30 | 403.40 | 47.10 | 482.70 | 82.50 |
| | 64 | 444.40 | 48.00 | 484.90 | 79.50 | 96.30 | 13.70 | 133.20 | 25.70 | 540.70 | 61.70 | 618.10 | 105.20 |
| | 96 | 377.70 | 40.20 | 395.90 | 65.00 | 93.30 | 13.70 | 124.80 | 23.60 | 471.00 | 53.90 | 520.70 | 88.60 |
| 150 | 0 | 305.50 | 33.80 | 340.30 | 56.30 | 77.40 | 10.80 | 104.00 | 21.10 | 382.90 | 44.60 | 444.30 | 77.40 |
| | 32 | 420.00 | 44.60 | 446.50 | 72.10 | 95.40 | 13.50 | 132.20 | 24.90 | 515.40 | 58.10 | 578.70 | 97.00 |
| | 64 | 561.30 | 63.20 | 629.30 | 100.40 | 94.20 | 16.60 | 152.40 | 28.80 | 655.50 | 79.80 | 781.70 | 129.20 |
| | 96 | 461.40 | 55.40 | 528.00 | 80.10 | 99.50 | 15.90 | 134.90 | 26.50 | 560.90 | 71.30 | 662.90 | 106.60 |
| 300 | 0 | 382.20 | 43.90 | 420.80 | 69.60 | 60.90 | 9.70 | 90.00 | 17.90 | 443.10 | 53.60 | 510.80 | 87.50 |
| | 32 | 729.50 | 84.80 | 806.60 | 131.20 | 120.70 | 20.50 | 183.80 | 35.30 | 850.20 | 105.30 | 990.40 | 166.50 |
| | 64 | 457.40 | 55.80 | 496.10 | 79.00 | 114.70 | 17.60 | 149.70 | 29.40 | 572.10 | 73.40 | 645.80 | 108.40 |
| | 96 | 418.60 | 57.80 | 492.10 | 77.90 | 92.30 | 17.50 | 144.80 | 26.60 | 510.90 | 75.30 | 636.90 | 104.50 |
| **L.S.D. at 0.05** | | **80.10** | **9.40** | **88.30** | **13.40** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **85.90** | **10.70** | **97.90** | **15.20** |

This increment in mineral uptake as a result of sulphur within phosphorus application may be due to the role of elemental sulphur application on increasing the availability of P-uptake. as mentioned by Kashirad and Bazargani ( 1972 ); Val Nikov et al ( 1973 ) and Heter ( 1985 ) which increased plant growth and mineral uptake. The increase in plant sulphur accumulation especially in the second season as a result of increasing level of elemental S-application may be due to the increase in soil-$504^{--}$ resulted after sulphur oxdition by soil micro-organisms ( Gabal, 1973 ). Although plants were supplied with a standard levels of N and K but S-application to soil increased N and K uptake. This result may be referred to the general increase in plant growth which removed higher quantities of most nutrients including N and K.

### 4.2.2.4. Effect of sulphur application on mineral content of tomato plant foliage at fruit set stage.

Data showed that P % in leaves and branches were gradually and significantly increased with increasing S-application from 0, 150 up to 300 Kg S/fed. in both seasons ( Table 25, Fig. 5 ). However N, K and S % in leaves or branches were not significantly affected by S-application in both seasons except for S % in branches in the second season which increased with increasing level of S-application from 0 up to 150 Kg S/fed. with no significant differences between 150 or 300 Kg S/fed.

This increment in P % of tomato plant foliage as a result of S-application may be due to the role of S-application on reducing soil-pH ( Kashirad. 1972, El-Rawi and Tajuldeen 1985 and Abd El-Fatth et al, 1990 ) and consequently increasing the availability of P-uptake ( Kashirad and Bazargani, 1972; Val Nikov et al, 1973 and Heter, 1985 ).

**Table (25): N, P, K and S percentage of tomato plant foliage at fruit set stage ( 70 days after transplanting ) as affected by sulphurs or phosphorus fertilization, during the seasons of 1993 and 1994.**

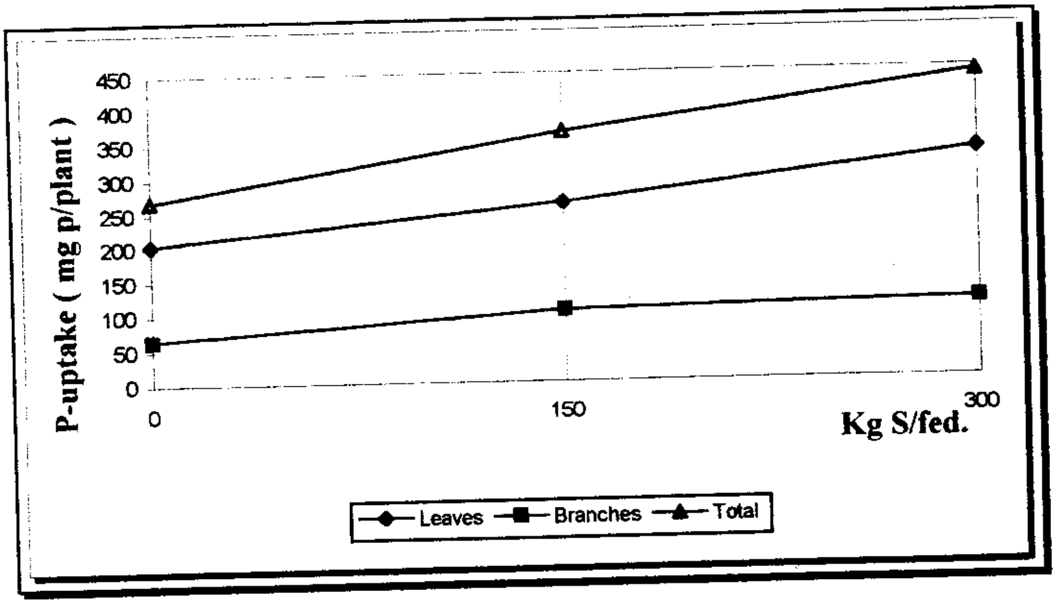
**Element % at early summer season, 1993**

| Treatments | Leaves | | | | Branches | | | |
|---|---|---|---|---|---|---|---|---|
| | N % | P % | K % | S % | N % | P % | K % | S % |
| **Kg S/fed.** | | | | | | | | |
| 0 | 5.12 | 0.46 | 5.36 | 0.74 | 3.66 | 0.35 | 3.36 | 0.66 |
| 150 | 4.58 | 0.48 | 5.25 | 0.73 | 3.74 | 0.37 | 3.31 | 0.68 |
| 300 | 4.91 | 0.51 | 5.27 | 0.74 | 3.58 | 0.39 | 3.32 | 0.68 |
| **L.S.D. at 0.05** | **N.S.** | **0.01** | **N.S.** | **N.S.** | **N.S.** | **0.01** | **N.S.** | **N.S.** |
| **Kg P2O5/fed.** | | | | | | | | |
| 0 | 4.99 | 0.43 | 5.25 | 0.73 | 3.38 | 0.34 | 3.32 | 0.67 |
| 32 | 4.99 | 0.47 | 5.25 | 0.74 | 3.77 | 0.36 | 3.38 | 0.67 |
| 64 | 4.77 | 0.50 | 5.37 | 0.73 | 3.72 | 0.38 | 3.33 | 0.67 |
| 96 | 4.72 | 0.52 | 5.31 | 0.75 | 3.77 | 0.39 | 3.29 | 0.68 |
| **L.S.D. at 0.05** | **N.S.** | **0.02** | **N.S.** | **N.S.** | **N.S.** | **0.01** | **N.S.** | **N.S.** |

**Element % at early summer season, 1994**

| Treatments | Leaves | | | | Branches | | | |
|---|---|---|---|---|---|---|---|---|
| | N % | P % | K % | S % | N % | P % | K % | S % |
| **Kg S/fed.** | | | | | | | | |
| 0 | 4.98 | 0.47 | 5.57 | 0.75 | 3.64 | 0.36 | 3.71 | 0.66 |
| 150 | 4.53 | 0.49 | 5.56 | 0.75 | 3.67 | 0.38 | 3.66 | 0.67 |
| 300 | 4.73 | 0.52 | 5.45 | 0.75 | 3.57 | 0.40 | 3.67 | 0.68 |
| **L.S.D. at 0.05** | **N.S.** | **0.01** | **N.S.** | **N.S.** | **N.S.** | **0.01** | **N.S.** | **0.01** |
| **Kg P2O5/fed.** | | | | | | | | |
| 0 | 4.76 | 0.46 | 5.37 | 0.71 | 3.52 | 0.35 | 3.59 | 0.63 |
| 32 | 4.86 | 0.49 | 5.60 | 0.76 | 3.66 | 0.38 | 3.71 | 0.67 |
| 64 | 4.81 | 0.50 | 5.60 | 0.76 | 3.71 | 0.39 | 3.69 | 0.69 |
| 96 | 4.55 | 0.52 | 5.54 | 0.75 | 3.62 | 0.40 | 3.73 | 0.67 |
| **L.S.D. at 0.05** | **N.S.** | **0.01** | **N.S.** | **0.02** | **N.S.** | **0.01** | **N.S.** | **0.02** |

**Fig ( 5 ): P-uptake ( mg p/plant ) of tomato plant foliage as affected by elemental sulphur application, at fruit setting stage.**



Concerning minerals uptake, data in Table ( 26 ) showed that P-uptake in leaves, branches and total plant foliage were gradually and significantly increased with increasing S-application. It reached its maximum at 300 Kg S/fed as shown in both seasons. N-uptake in leaves and / or branches also showed the same trend which increased with increasing S-application from 0 up to 150 Kg S/fed. with no more response by increasing level of S-application as shown in the second season. K-uptake of whole plant foliage was also increased gradually and significantly with increasing sulphur application however K-uptake in leaves and branches in the first season were not significantly affected by S-application. Total sulphur uptake was increased by increasing level of S-application from 0 up to 300 Kg S/fed., as shown in both seasons. This result was true for S-uptake in branches or leaves in the second season. Since S-uptake in leaves and branches in the first season were not significantly affected by elemental sulphur application .

This increment in P, N, K and S uptake as a result of S-application may be due to the role of elemental-S on the availability of phosphorus as reported by Kashirad and Bazargani ( 1972 ) Vol Nikov et al ( 1973 ). Heter ( 1985 ) reported that most of the added phosphorus to calcareous soil will be fixed as unavailable form for plant uptake. The addition of sulphur expected to increase the availability of phosphorus by increasing the solubility of Ca-phosphat compounds. Added to that increasing $HPO_4^{--}$ led to an increase in $K^+$- uptake according to the theory of cation - anion balance as reported by Kirkby and Mengl ( 1967 ).

**Table (26): N, P, K and S uptake of tomato plant foliage at fruit set stage ( 70 days after transplanting ) as affected by sulphur or phosphorus fertilization, during the seasons of 1993 and 1994.**

**Element uptake at early summer season, 1993**

| Treatments | Leaves ( mg/plant ) | | | | Branches ( mg/plant ) | | | | Total ( mg/plant ) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | P | K | S | N | P | K | S | N | P | K | S |
| **Kg S/fed.** | | | | | | | | | | | | |
| 0 | 990.80 | 90.90 | 1042.10 | 145.00 | 220.30 | 21.30 | 202.10 | 40.10 | 1211.10 | 112.20 | 1244.20 | 185.10 |
| 150 | 925.00 | 99.40 | 1069.40 | 149.90 | 309.90 | 30.70 | 273.30 | 55.90 | 1234.90 | 130.10 | 1342.70 | 205.80 |
| 300 | 962.80 | 102.20 | 1055.80 | 148.10 | 298.40 | 32.20 | 279.40 | 56.40 | 1261.20 | 134.40 | 1335.20 | 204.50 |
| **L.S.D. at 0.05** | **N.S** | **8.50** | **N.S.** | **N.S.** | **N.S.** | **8.50** | **N.S.** | **N.S.** | **N.S.** | **7.00** | **69.40** | **16.10** |
| **Kg P2O5/fed.** | | | | | | | | | | | | |
| 0 | 775.30 | 69.30 | 828.70 | 115.10 | 202.50 | 20.50 | 196.30 | 39.60 | 977.80 | 89.80 | 1025.00 | 154.70 |
| 32 | 955.40 | 88.50 | 977.30 | 138.70 | 252.00 | 24.80 | 229.70 | 45.40 | 1207.40 | 113.30 | 1207.00 | 184.10 |
| 64 | 1190.90 | 128.30 | 1360.70 | 187.50 | 409.20 | 42.20 | 370.40 | 74.60 | 1600.10 | 170.50 | 1731.10 | 262.10 |
| 96 | 946.50 | 103.90 | 1056.40 | 149.30 | 241.00 | 24.90 | 209.90 | 43.60 | 1187.50 | 128.80 | 1266.30 | 192.90 |
| **L.S.D. at 0.05** | **224.50** | **22.90** | **236.70** | **31.70** | **95.10** | **10.50** | **97.80** | **18.40** | **200.40** | **24.10** | **249.70** | **35.70** |

**Element uptake at early summer season, 1994**

| Treatments | Leaves ( mg/plant ) | | | | Branches ( mg/plant ) | | | | Total ( mg/plant ) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | P | K | S | N | P | K | S | N | P | K | S |
| **Kg S/fed.** | | | | | | | | | | | | |
| 0 | 2098.10 | 202.90 | 2344.10 | 318.50 | 858.90 | 63.90 | 643.70 | 116.70 | 2957.00 | 266.80 | 2987.80 | 435.20 |
| 150 | 2370.40 | 260.50 | 2932.90 | 396.00 | 1198.80 | 103.20 | 973.40 | 179.70 | 3569.20 | 363.70 | 3906.30 | 575.70 |
| 300 | 2983.00 | 330.80 | 3443.50 | 474.10 | 1302.90 | 112.10 | 1013.70 | 187.40 | 4285.90 | 442.90 | 4457.20 | 661.50 |
| **L.S.D. at 0.05** | **631.40** | **49.60** | **608.30** | **67.90** | **100.80** | **6.30** | **80.90** | **11.40** | **699.00** | **49.90** | **628.00** | **66.90** |
| **Kg P2O5/fed.** | | | | | | | | | | | | |
| 0 | 1468.10 | 143.90 | 1661.40 | 223.60 | 772.70 | 58.00 | 584.80 | 103.50 | 2240.80 | 201.90 | 2246.20 | 327.10 |
| 32 | 3029.80 | 308.10 | 3458.60 | 470.40 | 1229.60 | 98.60 | 940.40 | 172.70 | 4259.40 | 406.70 | 4399.00 | 643.10 |
| 64 | 2992.90 | 323.00 | 3526.40 | 481.80 | 1330.10 | 112.60 | 1034.20 | 196.20 | 4323.00 | 435.60 | 4560.60 | 678.00 |
| 96 | 2444.40 | 284.00 | 2981.00 | 409.10 | 1148.40 | 103.10 | 948.20 | 172.60 | 3592.80 | 367.10 | 3929.20 | 581.70 |
| **L.S.D. at 0.05** | **363.00** | **32.80** | **397.80** | **60.90** | **194.30** | **15.10** | **130.10** | **27.00** | **467.10** | **38.90** | **459.70** | **72.90** |

### 4.2.2.5. Effect of phosphorus application on mineral content of tomato plant foliage at fruit set stage.

Data in Table ( 25 ) showed that N % and K % in leaves or branches were not significantly affected by P-application in both seasons. However P % in leaves or branches was gradually and significantly increased by increasing P-application from 0, 32 up to 64 or 96 Kg $P_2O_5$/fed. as a general trend in both seasons. Data also showed that S% in leaves or branches increased with increasing P-application from 0 to 64 Kg $P_2O_5$/fed. and them decreased again with increasing level of P-fertilizer up to 96 Kg $P_2O_5$/fed. as shown in the second season but variances failed to reach the level of significance in the first season.

This increment in both P and S % of plant foliage may be due to the increase in the available $HPO_4^{--}$ and $SO_4^{--}$ in soil extract as a result of increasing level of P-fertilizer, especially the experimental soil is poor in P-content ( 0.61 % P in water extract ) and P was added as superphosphate fertilizer which include Ca $SO_4$ as on accompany product.

Concerning minerals uptake, data in Table ( 26 ) showed that N, P, K and S uptake in leaves and/or branches were significantly increased with increasing P-application form 0 up to 32 or 64 Kg $P_2O_5$/fed. in the first season. The second season also showed the same trend with no significant differences in minerals uptake between 32 and 64 Kg $P_2O_5$/fed. whereas, the highest level of 96 Kg $P_2O_5$/fed. decreased plant uptake of N, P, K and S in both seasons. This increment of minerals uptake as a result of P-application may be due to the effect of P-application on increasing root growth which consequently increased surface area to minerals uptake ( Devlin and Witham, 1986 ) as well as improved tomato plant growth. It was clear that N and K uptake showed a contra trend than its percentage.

This result may be due to the distribution of these two minerals in plant organs in a large vegetative growth encouraged by P-application.

### 4.2.2.6. Effect of phosphorus within sulphur application on minerals content of tomato plant foliage at fruit set stage.

Table ( 27 ) showed that N, K and S % in leaves and branches were not significantly affected by any of the used sulphur within phosphorus treatments in both seasons. However, P % in leaves and branches were increased significantly by increasing levels of sulphur within phosphorus application. The highest values were recorded with 300 Kg S + 96 Kg $P_2O_5$/fed. followed by 300 Kg S + 64 Kg $P_2O_5$ and 150 Kg S + 96 Kg $P_2O_5$ per feddan. The lowest P % was found in control plants.

This result may be due to the role of S-application on depressing soil-pH and consequently increasing the available soil phosphorus and consequently P-uptake by plant roots was increased ( Kashirad and Bazargani, 1972; Val Nikov et al, 1973 and Abd El-Fatth et al, 1990 ). Added to that increasing level of P-fertilizer led to an increase in the availability of soil phosphates which consequently increased $HPO_4^{--}$ uptake.

Concerning the minerals uptake, data in Table ( 28 ) showed that N, P, K and S uptake were significantly increased by increasing the application level of sulphur up to 300 Kg S/fed. within phosphorus up to 64 Kg $P_2O_5$/fed. Therefore, the highest values were recorded with 300 Kg S + 32 or 64 Kg $P_2O_5$/fed. followed by 150 Kg S +32 or 64 Kg $P_2O_5$/fed. the lowest values were recorded with the control, in the second season. Heavy application of 300 Kg S + 96 Kg $P_2O_5$/fed. depressed all minerals ( N, P, K and S ) uptake. Although the same trend was found in most the interaction treatments in the first season but variances failed to reach the level of significance.

Table (27): N, P, K and S percentage of tomato plant foliage at fruit set stage ( 70 days after transplanting ) as affected by sulphur within phosphorus fertilization, during the seasons of 1993 and 1994.

**Early summer season, 1993**

| Treatments | | Leaves | | | | Branches | | | |
|---|---|---|---|---|---|---|---|---|---|
| Kg S/fed. | Kg P2O5/fed. | N % | P % | K % | S % | N % | P % | K % | S % |
| 0 | 0 | 5.16 | 0.42 | 5.23 | 0.73 | 3.50 | 0.33 | 3.36 | 0.65 |
| | 32 | 5.33 | 0.45 | 5.43 | 0.75 | 3.83 | 0.35 | 3.36 | 0.66 |
| | 64 | 5.16 | 0.47 | 5.43 | 0.75 | 3.66 | 0.36 | 3.33 | 0.67 |
| | 96 | 4.83 | 0.50 | 5.36 | 0.75 | 3.66 | 0.37 | 3.40 | 0.68 |
| 150 | 0 | 5.00 | 0.44 | 5.33 | 0.73 | 3.33 | 0.35 | 3.30 | 0.67 |
| | 32 | 4.50 | 0.48 | 5.16 | 0.73 | 4.00 | 0.36 | 3.36 | 0.68 |
| | 64 | 4.50 | 0.52 | 5.30 | 0.73 | 3.83 | 0.38 | 3.33 | 0.68 |
| | 96 | 4.33 | 0.51 | 5.23 | 0.74 | 3.83 | 0.39 | 3.26 | 0.69 |
| 300 | 0 | 4.83 | 0.45 | 5.20 | 0.73 | 3.33 | 0.35 | 3.30 | 0.69 |
| | 32 | 5.16 | 0.50 | 5.16 | 0.75 | 3.50 | 0.38 | 3.43 | 0.68 |
| | 64 | 4.66 | 0.52 | 5.40 | 0.73 | 3.66 | 0.40 | 3.33 | 0.67 |
| | 96 | 5.00 | 0.55 | 5.33 | 0.75 | 3.83 | 0.41 | 3.23 | 0.68 |
| **L.S.D. at 0.05** | | **N.S.** | **0.02** | **N.S.** | **N.S.** | **N.S.** | **0.01** | **N.S.** | **N.S.** |

**Early summer season, 1994**

| Treatments | | Leaves | | | | Branches | | | |
|---|---|---|---|---|---|---|---|---|---|
| Kg S/fed. | Kg P2O5/fed. | N % | P % | K % | S % | N % | P % | K % | S % |
| 0 | 0 | 4.80 | 0.45 | 5.43 | 0.72 | 3.60 | 0.34 | 3.60 | 0.64 |
| | 32 | 5.06 | 0.47 | 5.70 | 0.75 | 3.76 | 0.36 | 3.70 | 0.65 |
| | 64 | 5.23 | 0.48 | 5.56 | 0.77 | 3.80 | 0.37 | 3.73 | 0.69 |
| | 96 | 4.83 | 0.50 | 5.60 | 0.76 | 3.40 | 0.38 | 3.83 | 0.69 |
| 150 | 0 | 4.76 | 0.46 | 5.36 | 0.71 | 3.53 | 0.36 | 3.63 | 0.63 |
| | 32 | 4.46 | 0.48 | 5.60 | 0.76 | 3.60 | 0.38 | 3.70 | 0.69 |
| | 64 | 4.70 | 0.50 | 5.70 | 0.76 | 3.70 | 0.40 | 3.60 | 0.70 |
| | 96 | 4.20 | 0.52 | 5.60 | 0.76 | 3.86 | 0.40 | 3.73 | 0.66 |
| 300 | 0 | 4.73 | 0.47 | 5.33 | 0.72 | 3.43 | 0.36 | 3.56 | 0.64 |
| | 32 | 5.06 | 0.52 | 5.50 | 0.76 | 3.63 | 0.40 | 3.73 | 0.68 |
| | 64 | 4.50 | 0.53 | 5.56 | 0.76 | 3.63 | 0.42 | 3.76 | 0.70 |
| | 96 | 4.63 | 0.56 | 5.43 | 0.75 | 3.60 | 0.43 | 3.63 | 0.68 |
| **L.S.D. at 0.05** | | **N.S.** | **0.01** | **N.S.** | **N.S.** | **N.S.** | **0.02** | **N.S.** | **N.S.** |

**Table (28): N, P, K and S uptake of tomato plant foliage at fruit set stage ( 70 days after transplanting ) as affected by sulphur within phosphorus fertilization, during the seasons of 1993 and 1994.**

**Early summer season, 1993**

| Treatments | | Leaves ( mg/plant ) | | | | Branches ( mg/plant ) | | | | Total ( mg/plant ) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kg S/fed. | Kg P2O5/fed. | N | P | K | S | N | P | K | S | N | P | K | S |
| 0 | 0 | 661.70 | 53.70 | 656.90 | 92.30 | 219.00 | 20.70 | 208.30 | 40.50 | 880.70 | 74.40 | 865.20 | 132.80 |
| | 32 | 1070.00 | 90.20 | 1090.60 | 151.40 | 231.00 | 21.20 | 203.20 | 39.80 | 1301.00 | 111.40 | 1293.80 | 191.20 |
| | 64 | 1172.70 | 108.90 | 1242.80 | 172.10 | 252.70 | 25.50 | 233.00 | 47.30 | 1425.40 | 134.40 | 1475.80 | 219.40 |
| | 96 | 1059.10 | 110.80 | 1178.30 | 164.50 | 178.50 | 18.00 | 164.00 | 33.10 | 1237.60 | 128.80 | 1342.30 | 197.60 |
| 150 | 0 | 956.10 | 85.10 | 1021.40 | 140.70 | 190.80 | 19.90 | 186.70 | 37.90 | 1146.90 | 105.00 | 1208.10 | 178.60 |
| | 32 | 858.80 | 91.60 | 988.10 | 140.90 | 240.20 | 21.70 | 202.80 | 40.60 | 1099.00 | 113.30 | 1190.90 | 181.50 |
| | 64 | 993.80 | 116.10 | 1196.70 | 166.10 | 499.20 | 49.40 | 433.30 | 88.60 | 1493.00 | 165.50 | 1630.00 | 254.70 |
| | 96 | 891.40 | 105.00 | 1071.50 | 151.90 | 309.40 | 32.10 | 270.40 | 56.80 | 1200.80 | 137.10 | 1341.90 | 208.70 |
| 300 | 0 | 708.30 | 69.20 | 807.80 | 112.50 | 197.70 | 21.00 | 194.10 | 40.60 | 906.00 | 90.20 | 1001.90 | 153.10 |
| | 32 | 847.50 | 83.90 | 853.30 | 124.00 | 284.80 | 31.50 | 283.30 | 56.00 | 1132.30 | 115.40 | 1136.60 | 180.00 |
| | 64 | 1406.20 | 159.90 | 1642.60 | 224.40 | 475.90 | 51.70 | 444.90 | 87.90 | 1882.10 | 211.60 | 2087.50 | 312.30 |
| | 96 | 889.20 | 96.00 | 919.60 | 131.60 | 235.30 | 24.80 | 195.50 | 41.10 | 1124.50 | 120.80 | 1115.10 | 172.70 |
| **L.S.D. at 0.05** | | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **347.10** | **N.S.** | **N.S.** | **N.S.** |

**Early summer season, 1994**

| Treatments | | Leaves ( mg/plant ) | | | | Branches ( mg/plant ) | | | | Total ( mg/plant ) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kg S/fed. | Kg P2O5/fed. | N | P | K | S | N | P | K | S | N | P | K | S |
| 0 | 0 | 858.00 | 80.60 | 973.80 | 129.00 | 618.30 | 43.90 | 467.50 | 82.90 | 1476.30 | 124.50 | 1441.30 | 211.90 |
| | 32 | 2278.60 | 211.40 | 2565.50 | 337.00 | 678.80 | 49.00 | 492.20 | 87.30 | 2957.40 | 260.40 | 3057.70 | 424.30 |
| | 64 | 2528.20 | 235.00 | 2696.50 | 375.20 | 1047.50 | 75.30 | 748.10 | 139.40 | 3575.70 | 310.30 | 3444.60 | 514.60 |
| | 96 | 2727.80 | 284.60 | 3140.80 | 432.90 | 1091.10 | 87.60 | 867.10 | 157.50 | 3818.90 | 372.20 | 4007.90 | 590.40 |
| 150 | 0 | 1736.80 | 168.00 | 1949.80 | 260.70 | 838.20 | 63.70 | 639.80 | 111.30 | 2575.00 | 231.70 | 2589.60 | 372.00 |
| | 32 | 2529.00 | 271.70 | 3146.00 | 426.90 | 1270.80 | 107.30 | 1043.20 | 195.20 | 3799.80 | 379.00 | 4189.20 | 622.10 |
| | 64 | 2785.50 | 298.50 | 3371.30 | 452.10 | 1428.80 | 121.60 | 1090.90 | 213.10 | 4214.30 | 420.10 | 4462.20 | 665.20 |
| | 96 | 2430.40 | 303.80 | 3264.60 | 444.60 | 1257.50 | 120.40 | 1119.80 | 199.40 | 3687.90 | 424.20 | 4384.40 | 644.00 |
| 300 | 0 | 1809.70 | 183.10 | 2060.60 | 281.10 | 861.60 | 66.40 | 647.20 | 116.40 | 2671.30 | 249.50 | 2707.80 | 397.50 |
| | 32 | 4282.00 | 441.20 | 4664.30 | 647.40 | 1739.20 | 139.70 | 1286.00 | 235.80 | 6021.20 | 580.90 | 5950.30 | 883.20 |
| | 64 | 3665.10 | 435.50 | 4511.40 | 618.20 | 1514.10 | 141.00 | 1263.80 | 236.30 | 5179.20 | 576.50 | 5775.20 | 854.50 |
| | 96 | 2175.20 | 263.60 | 2537.80 | 349.80 | 1096.70 | 101.50 | 857.80 | 161.10 | 3271.90 | 365.10 | 3395.60 | 510.90 |
| **L.S.D. at 0.05** | | **628.70** | **66.90** | **689.10** | **105.60** | **336.60** | **26.30** | **226.60** | **46.80** | **809.10** | **67.40** | **796.20** | **126.30** |

This increment in minerals uptake as a result of sulphur within phosphporus application may be due to the rate of S-application on depressing soil-pH and increasing availability of phosphorus to plant uptake (Kashirad and Bazargani, 1972; Val Nikov et al, 1973 and Abd El-Fatth et al, 1990) As well as increasing P-application led to an increase in root growth and consequently increased surface area which increased minerals uptake ( Devlin and Witham, 1986 ). Furthermore, increasing $HPO_4^{--}$ uptake may increase $NH4^+$ and $K^+$ uptake to keep the anion-cation balance in plant tissues ( Kirkby and Mengel, 1967 ). Also the increase in $SO_4^{--}$ uptake by tomato plants may be referred to the increase in available $SO_4^{--}$ in the soil after the oxidation of elemental- S to $SO_4^{--}$ by soil micro organisms ( Mcgeorge and Green, 1935 ).

### 4.2.3. Fruit yield:

### 4.2.3.1. Effect of sulphur application on tomato fruit yield.

Data in Table ( 29 ) showed that early, marketable, unmarketable and total yield were not significantly affected by S-application in both seasons, except for the unmarketable yield in the first season which was decreased with increasing sulphur application up to 150 or 300 Kg S/fed. as compared with the control. This result may be referred to the role of sulphur as a fungicide which improved fruit quality and decreased the unmarketable yield. The non response of elemental S-application to increase fruit early, marketable and total yield are in harmony with those of Zidan et al ( 1973 ) and Cerda et al ( 1984 ). These results may be referred also to that the experimental soil had no shortage in S-content especially S-deficiency was not pronounced in the control treatments, which sulphur was not added.

**Table (29): Tomato fruit yield and its components as affected by sulphur or phosphorus fertilization, during early summer season of 1993 and 1994.**

**Early summer season, 1993**

| Treatments | Early yield ton/fed. | Marketable yield ton/fed. | Unmarketable yield ton/fed. | Total yield ton/fed. |
|---|---|---|---|---|
| **Kg S/fed.** | | | | |
| 0 | 1.16 | 7.00 | 0.43 | 7.43 |
| 150 | 1.45 | 7.50 | 0.30 | 7.80 |
| 300 | 1.51 | 7.60 | 0.35 | 7.95 |
| **L.S.D. at 0.05** | **N.S.** | **N.S.** | **0.06** | **N.S.** |
| **Kg P2O5/fed.** | | | | |
| 0 | 1.13 | 6.56 | 0.25 | 6.81 |
| 32 | 1.42 | 6.84 | 0.26 | 7.10 |
| 64 | 1.65 | 8.93 | 0.49 | 9.42 |
| 96 | 1.29 | 7.13 | 0.44 | 7.57 |
| **L.S.D. at 0.05** | **N.S.** | **0.85** | **0.10** | **0.83** |

**Early summer season, 1994**

| Treatments | Early yield ton/fed. | Marketable yield ton/fed. | Unmarketable yield ton/fed. | Total yield ton/fed. |
|---|---|---|---|---|
| **Kg S/fed.** | | | | |
| 0 | 2.02 | 13.11 | 0.44 | 13.55 |
| 150 | 1.76 | 9.87 | 0.50 | 10.36 |
| 300 | 1.33 | 9.77 | 0.46 | 10.23 |
| **L.S.D. at 0.05** | **N.S.** | **N.S.** | **N.S.** | **N.S.** |
| **Kg P2O5/fed.** | | | | |
| 0 | 1.61 | 8.67 | 0.39 | 9.06 |
| 32 | 1.88 | 12.37 | 0.50 | 12.87 |
| 64 | 1.97 | 12.13 | 0.54 | 12.67 |
| 96 | 1.36 | 10.49 | 0.43 | 10.92 |
| **L.S.D. at 0.05** | **N.S.** | **2.49** | **0.10** | **2.48** |

Table (29)

### 4.2.3.2. Effect of phosphorus application on tomato fruit yield.

Table ( 29 ) showed that early, marketable and total yield were significantly increased with increasing P-application up to 64 Kg $P_2O_5$/fed. as compared with all the studied P-levels, in the first season. Results also showed the same trend in the second season; 32 or 64 Kg $P_2O_5$/fed. gave similar marketable and total yield and higher than the control. Early yield was gradually increased with increasing P-level from 0, 32 up to 64 Kg $P_2O_5$/fed. and then early, marketable or total yield were decreased again with 96 Kg $P_2O_5$/fed., as shown in the second season. ***Generally, 64 Kg $P_2O_5$/fed. seemed to be the optimum level of superphosphate for early, marketable and total yield production under such conditions of this experiment.***

This increment in tomato fruit yield as a result of P-application at a moderate level ( 64 Kg $P_2O_5$/fed. ) may be referred to the increase in vegetative growth (Tables, 17 & 19) and minerals uptake (Tables, 22 & 26 ) of tomato plants supplied with this level. This result agree with those of Bhatangar and Pandita (1979), Abdalla et al ( 1979 ). Ramakrishma and Sulladmath ( 1979 ) reported that P-application increased early, marketable and total yield. Gibson and Pill (1983) and Castellance et al ( 1982 ) also reached to similar results, reporting that the highest yield was obtained with a rate of 508 Kg P/ha but the highest economic rate was 405 Kg P/ha compared with P-rates ranging from 0 to 900 Kg P/ha. Moreover, Candilo et al ( 1993 ) found that increasing P-application led to a significant linear increase in marketable yield.

### 4.2.3.3. Effect of sulphur within phosphorus application on tomato fruit yield.

Data in Table ( 30 ) showed that total yield was significantly differed due to the interaction treatments of sulphur within phosphorus in both seasons. Early and marketable yield also showed the same trend but only in one season; in the second and first seasons for each respectively. The highest production of early, total and marketable fruit yield was recorded with 64 Kg $P_2O_5$/fed. within 0 Kg S/fed. and the lowest values were recored with control, as a general trend for both seasons. Moreover, plants fertilized with 300 Kg S+ 64 Kg $P_2O_5$/fed. gave the highest marketable and total yield and those received 64 or 96 Kg $P_2O_5$/fed. with no S-application gave the highest early yield. It was clear that increasing elemental sulphur application significantly decreased yield earliness especially within the high P-level of 64 and 96 Kg $P_2O_5$/fed. This result may be due to the time required for S-oxidation to sulphates before plants can use it. i.e. sulphur response or effect will appear later on total yield after elemental sulphur is completely oxidized. In this respect some growers recommend S-application during field preparation and 2-3 weeks before growing. Generally data showed that the moderate level of P-application ( 64 Kg $P_2O_5$/fed. ) within all S-levels gave the highest total and marketable yield as compared with the higher or lower levels of P-application within all levels of S-application. This result may be due to that this moderate level of P led to an increase in vegetative growth and minerals uptake by tomato plant .

This result agree with those of Bhatangar and Pandita ( 1979 ); Ramakrishma and Sulladmath ( 1979 ); Abdalla et al ( 1979 ) and Candilo et al ( 1993 ) reporting that P-application increased early, marketable and total yield . Moreover, Gibson and Pill(1983) and Castellane et al ( 1982 ) reported that the highest economic rate was 405 Kg P/ha compared with P-applied from 0 to 900 Kg P/ha.

**Table (30): Tomato fruit yield and its companioned as affected by sulphur within phosphorus fertilization, during early summer season of 1993 and 1994.**

**Early summer season, 1993**

| Treatments | | Early yield | Marketable yield | Unmarketable yield | Total yield |
|---|---|---|---|---|---|
| Kg S/fed. | Kg P2O5/fed. | ton/fed. | ton/fed. | ton/fed. | ton/fed. |
| 0 | 0 | 0.92 | 5.63 | 0.29 | 5.92 |
| | 32 | 1.04 | 5.73 | 0.27 | 6.00 |
| | 64 | 1.56 | 8.80 | 0.71 | 9.51 |
| | 96 | 1.11 | 7.85 | 0.45 | 8.31 |
| 150 | 0 | 1.31 | 7.45 | 0.25 | 7.71 |
| | 32 | 1.84 | 7.97 | 0.27 | 8.23 |
| | 64 | 1.47 | 8.34 | 0.31 | 8.65 |
| | 96 | 1.19 | 6.23 | 0.37 | 6.60 |
| 300 | 0 | 1.16 | 6.59 | 0.21 | 6.81 |
| | 32 | 1.37 | 6.83 | 0.25 | 7.08 |
| | 64 | 1.92 | 9.66 | 0.46 | 10.12 |
| | 96 | 1.57 | 7.31 | 0.49 | 7.79 |
| **L.S.D. at 0.05** | | **N.S.** | **1.48** | **0.17** | **1.44** |

**Early summer season, 1994**

| Treatments | | Early yield | Marketable yield | Unmarketable yield | Total yield |
|---|---|---|---|---|---|
| Kg S/fed. | Kg P2O5/fed. | ton/fed. | ton/fed. | ton/fed. | ton/fed. |
| 0 | 0 | 1.00 | 8.23 | 0.38 | 8.61 |
| | 32 | 1.81 | 14.36 | 0.45 | 14.81 |
| | 64 | 3.03 | 15.70 | 0.51 | 16.21 |
| | 96 | 2.24 | 14.16 | 0.40 | 14.56 |
| 150 | 0 | 1.80 | 8.45 | 0.34 | 8.79 |
| | 32 | 2.17 | 11.63 | 0.53 | 12.16 |
| | 64 | 1.97 | 10.89 | 0.67 | 11.56 |
| | 96 | 1.11 | 8.49 | 0.45 | 8.95 |
| 300 | 0 | 2.03 | 9.33 | 0.44 | 9.77 |
| | 32 | 1.66 | 11.13 | 0.52 | 11.65 |
| | 64 | 0.92 | 9.80 | 0.45 | 10.25 |
| | 96 | 0.73 | 8.82 | 0.45 | 9.27 |
| **L.S.D. at 0.05** | | **0.91** | **N.S.** | **N.S.** | **N.S.** |

*It could be concluded from data of that the most effective treatment on increasing early yield is to added 150 Kg S/fed during soil management associated with 32 Kg $P_2O_5$/fed. Moreover 64 Kg $P_2O_5$/fed without S application gave the best results of early, marketable and total yield production, these increment were 203 %, 90,76 % 88,26 % and for each respectively over than the control in the second season.*

### 4.2.4. Tomato fruit quality:

#### 4.2.4.1. Effect of sulphur application on tomato fruit quality.

Data in Table ( 31 ) showed that fruit length, fruit diameter, average fruit weight, fruit dry weight %, TSS% and vitamin-C content were not significantly affected by S-application in both seasons. This result agrees with those of Lotstein et al ( 1983 ) reported that TSS and ascorbic acid content of tomato fruits were not significantly affected by S-application.

On the other hand, fruit dry weight was increased significantly with increasing level of S-application in one season only i.e. fruit dry weight % was increased by increasing level of S-application from 0 up to 150 Kg S/fed. with no significant differences between 150 or 300 Kg S/fed. as shown in the second season. Moreover, total acidity of tomato juice was also increased gradually and significantly with increasing level of S-application in the first season only. This result agrees with Zidan et al ( 1973 ) who mentioned that titratable acidity was increased with increasing S application. Moreover, Szwonek et al ( 1990 ) found that dry mater content of tomato fruits was increased by increasing rate of S-application.

**Table (31): Tomato fruit quality as affected by sulphur or phosphorus fertilization, during early summer season of 1993 and 1994.**

**Early summer season, 1993**

| Treatments | Fruit L. Cm. | Fruit D. Cm. | Fruit W. g/fruit | Fruit dry W % | T.S.S. % | Total acidity mg/l. | Vitamin C mg/100cm3 |
|---|---|---|---|---|---|---|---|
| **Kg S/fed.** | | | | | | | |
| 0 | 5.68 | 5.29 | 87.25 | 5.51 | 4.03 | 585.50 | 21.03 |
| 150 | 5.71 | 5.26 | 89.46 | 5.27 | 4.05 | 616.00 | 19.97 |
| 300 | 5.69 | 5.46 | 96.53 | 5.50 | 4.10 | 658.36 | 19.46 |
| **L.S.D. at 0.05** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **11.05** | **N.S.** |
| **Kg P2O5/fed.** | | | | | | | |
| 0 | 5.66 | 5.28 | 90.56 | 5.44 | 4.20 | 667.73 | 23.70 |
| 32 | 5.51 | 5.31 | 89.78 | 5.41 | 3.91 | 573.73 | 17.05 |
| 64 | 5.72 | 5.34 | 93.59 | 5.52 | 4.02 | 616.53 | 18.41 |
| 96 | 5.87 | 5.42 | 90.39 | 5.32 | 4.11 | 621.82 | 21.46 |
| **L.S.D. at 0.05** | **0.22** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **14.82** | **1.59** |

**Early summer season, 1994**

| Treatments | Fruit L. Cm. | Fruit D. Cm. | Fruit W. g/fruit | Fruit dry W % | T.S.S. % | Total acidity mg/l. | Vitamin C mg/100cm3 |
|---|---|---|---|---|---|---|---|
| **Kg S/fed.** | | | | | | | |
| 0 | 6.75 | 5.86 | 94.10 | 5.17 | 4.46 | 532.09 | 20.96 |
| 150 | 6.69 | 5.91 | 94.49 | 5.76 | 4.26 | 513.13 | 21.58 |
| 300 | 6.65 | 5.92 | 94.74 | 5.82 | 4.29 | 515.59 | 21.40 |
| **L.S.D. at 0.05** | **N.S.** | **N.S.** | **N.S.** | **0.58** | **N.S.** | **N.S.** | **N.S.** |
| **Kg P2O5/fed.** | | | | | | | |
| 0 | 6.51 | 5.77 | 85.32 | 5.49 | 4.30 | 512.38 | 19.68 |
| 32 | 6.80 | 5.96 | 96.61 | 5.38 | 4.33 | 527.52 | 22.05 |
| 64 | 6.73 | 5.97 | 101.68 | 5.51 | 4.31 | 494.74 | 21.64 |
| 96 | 6.76 | 5.88 | 94.16 | 5.95 | 4.42 | 546.43 | 21.88 |
| **L.S.D. at 0.05** | **N.S.** | **N.S.** | **10.04** | **0.31** | **N.S.** | **19.16** | **N.S.** |

### 4.2.4.2. Effect of phosphorus application on tomato fruit quality.

Data in Table ( 31 ) showed that fruit length, fruit diameter and TSS % were not significantly affected by P-application in both seasons. Although, average fruit weight and fruit weight % showed the same trend in the first season but they were significantly increased by increasing P-application in the second season. All P-levels improved average fruit weight than the control with no significant difference among P-levels. Moreover fruit dry weight % was significantly increased by increasing P-application up to 96 Kg $P_2O_5$/fed. Whereas, total acidity and Vitamin-C content of tomato juice did not show a definite trend in both seasons. fruit acidity and Vitamin-C were decreased by increasing level of P-application in the first season but a contra trend was noticed in the second one. This result agrees with those of Al-Afifi et al (1991) who found that application of phosphorus significantly increased average fruit weight. Moreover, Dimitrov and Rankov ( 1979 ) found that phosphorus applied once in 3- years at 720 Kg $P_2O_5$/ha slightly increased TSS% and sugar content of the fruit but reduced vitamin -C content compared with split application of 240 Kg $P_2O_5$/ha every year.

### 4.2.4.3. Effect of sulphur within phosphorus application on tomato fruit quality.

Data in Table ( 32 ) showed that fruit length, fruit diameter, average fruit weight and fruit dry weight % were not significantly affected by this interaction treatments in both seasons except for fruit dry weight % in the second season, which significantly increased with adding 96 Kg $P_2O_5$/fed within all levels of S-application. The lowest values were recorded with the control. Concerning the total acidity and vitamin-C content, they were significantly affected by this interaction treatments in the first season. Data showed that increasing level of S-application up to 150 or 300 Kg S/fed. increased fruit acidity and vitamin-C content within all P-level.

This result agrees with Zidan et al ( 1973 ) working on fruit acidity and Szwonek et al ( 1990 ) working on dry matter content of tomato fruit.

**Table (32): Tomato fruit quality as affected by sulphur within phosphorus fertilization, during early summer season of 1993 and 1994.**

**Early summer season, 1993**

| Treatments | | Fruit L. | Fruit D. | Fruit W. | Fruit dry W. | T.S.S. | Total acidity | Vitamin C |
|---|---|---|---|---|---|---|---|---|
| Kg S/fed. | Kg P2O5/fed. | Cm. | Cm. | g/fruit | % | % | mg/l. | mg/100cm3 |
| 0 | 0 | 5.65 | 5.31 | 88.89 | 5.67 | 4.26 | 665.60 | 22.20 |
| | 32 | 5.46 | 5.24 | 83.15 | 5.52 | 3.86 | 466.80 | 20.00 |
| | 64 | 5.76 | 5.17 | 86.23 | 5.50 | 3.93 | 601.60 | 17.53 |
| | 96 | 5.86 | 5.44 | 90.75 | 5.34 | 4.06 | 608.00 | 24.40 |
| 150 | 0 | 5.43 | 5.18 | 83.82 | 5.23 | 4.06 | 588.80 | 22.20 |
| | 32 | 5.67 | 5.21 | 90.89 | 5.37 | 3.93 | 595.20 | 13.30 |
| | 64 | 5.84 | 5.29 | 93.37 | 5.40 | 4.06 | 627.20 | 22.20 |
| | 96 | 5.89 | 5.37 | 89.76 | 5.09 | 4.13 | 652.80 | 22.20 |
| 300 | 0 | 5.91 | 5.36 | 98.98 | 5.42 | 4.26 | 748.80 | 26.70 |
| | 32 | 5.41 | 5.48 | 95.31 | 5.36 | 3.93 | 659.20 | 17.80 |
| | 64 | 5.58 | 5.56 | 101.16 | 5.68 | 4.06 | 620.80 | 15.50 |
| | 96 | 5.88 | 5.46 | 90.68 | 5.55 | 4.13 | 604.60 | 17.80 |
| **L.S.D. at 0.05** | | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **25.67** | **2.76** |

**Early summer season, 1994**

| Treatments | | Fruit L. | Fruit D. | Fruit W. | Fruit dry W. | T.S.S. | Total acidity | Vitamin C |
|---|---|---|---|---|---|---|---|---|
| Kg S/fed. | Kg P2O5/fed. | Cm. | Cm. | g/fruit | % | % | mg/l. | mg/100cm3 |
| 0 | 0 | 6.26 | 5.43 | 84.03 | 4.92 | 4.40 | 518.56 | 18.66 |
| | 32 | 7.10 | 6.16 | 92.20 | 4.89 | 4.60 | 531.86 | 21.26 |
| | 64 | 6.53 | 5.70 | 101.16 | 5.15 | 4.20 | 490.83 | 21.40 |
| | 96 | 7.13 | 6.16 | 99.03 | 5.70 | 4.67 | 587.10 | 22.53 |
| 150 | 0 | 6.56 | 5.83 | 85.03 | 5.57 | 4.20 | 505.13 | 21.16 |
| | 32 | 6.96 | 6.06 | 98.13 | 5.34 | 4.26 | 529.53 | 21.26 |
| | 64 | 6.80 | 6.03 | 102.56 | 6.04 | 4.40 | 497.13 | 22.03 |
| | 96 | 6.43 | 5.73 | 92.23 | 6.09 | 4.20 | 520.73 | 21.26 |
| 300 | 0 | 6.70 | 6.06 | 86.90 | 5.98 | 4.30 | 513.40 | 19.23 |
| | 32 | 6.33 | 5.66 | 99.50 | 5.90 | 4.13 | 521.16 | 23.03 |
| | 64 | 6.86 | 6.20 | 101.33 | 5.33 | 4.33 | 496.26 | 21.50 |
| | 96 | 6.73 | 5.76 | 91.23 | 6.07 | 4.40 | 531.46 | 21.86 |
| **L.S.D. at 0.05** | | **N.S.** | **N.S.** | **N.S.** | **0.55** | **N.S.** | **N.S.** | **N.S.** |

## 4.3. THIRD EXPERIMENT:

**Effect of nitrogen and/or phosphorus on vegetative growth, yield and fruit quality of tomato:**

### 4.3.1. Effect of nitrogen and/or phosphorus on vegetative growth of tomato plant.

Data in Tables( 34 & 35, 37 & 38 ) showed that nitrogen within phosphorus application had no significant effect on plant growth parameters i.e. plant height, number of leaves or branches per plant, fresh and dry weight of leaves and /or branches. This trend was true in both seasons when plant growth evaluated at flowering or fruit setting stage.

Therefore, the main effect data should be taken in consideration; Tables ( 33 & 36 ) show that increasing level of nitrogen application up to 120 or 180 Kg N/fed. significantly increased plant growth. Moreover, increasing level of P-application up to 64 Kg $P_2O_5$/fed. significantly increased plant growth. Heavy application of nitrogen at 240 or 300 Kg N/fed. or phosphorus at 96 Kg $P_2O_5$/fed. depressed plant growth.

The favorable effect of moderate level of nitrogen or phosphorus application on plant growth as well as the unfavorable effect of heavy N or P application on plant growth have been discussed in ( 4.1.1. and 4.2.1. ) of the first and second experiments, respectively .

**Table (33): Vegetative growth of tomato plants, at flowering ( 50 days after transplanting ) as affected by nitrogen and phosphorus application, during the early summer seasons of 1993 and 1994.**

**Early summer season, 1993**

| Treatments | Plant ht. Cm. | No. of leaves / plant | No. of branche / plant | Fresh weight ( g / plant ) leaves | branches | total | Dry weight ( g / plant ) leaves | branches | total |
|---|---|---|---|---|---|---|---|---|---|
| **Kg P2O5/fed.** | | | | | | | | | |
| 0 | 40.90 | 13.60 | 1.80 | 11.89 | 6.42 | 18.31 | 2.54 | 0.83 | 3.37 |
| 64 | 39.70 | 14.40 | 2.00 | 14.42 | 6.19 | 20.61 | 2.57 | 0.92 | 3.49 |
| 80 | 37.80 | 13.70 | 1.60 | 13.05 | 5.70 | 18.75 | 2.21 | 0.93 | 3.14 |
| 96 | 38.70 | 13.60 | 1.70 | 13.05 | 5.82 | 18.87 | 2.43 | 0.87 | 3.30 |
| **L.S.D. at 0.05** | **N.S.** | **N.S.** | **N.S.** | **1.30** | **N.S.** | **1.02** | **N.S.** | **0.04** | **0.08** |
| **Kg N/fed.** | | | | | | | | | |
| 0 | 39.70 | 13.10 | 1.60 | 11.37 | 6.03 | 17.40 | 2.11 | 0.83 | 2.94 |
| 120 | 38.70 | 14.80 | 1.60 | 14.21 | 7.14 | 21.35 | 2.74 | 1.10 | 3.84 |
| 180 | 38.90 | 15.30 | 2.10 | 15.44 | 7.12 | 22.56 | 2.86 | 1.01 | 3.87 |
| 240 | 41.70 | 13.20 | 1.70 | 12.96 | 4.93 | 17.89 | 2.25 | 0.74 | 2.99 |
| 300 | 37.40 | 12.80 | 1.70 | 11.54 | 4.94 | 16.48 | 2.23 | 0.76 | 2.99 |
| **L.S.D. at 0.05** | **N.S.** | **1.30** | **N.S.** | **1.53** | **0.32** | **2.14** | **N.S.** | **N.S.** | **0.51** |

**Early summer season, 1994**

| Treatments | Plant ht. Cm. | No. of leaves / plant | No. of branche / plant | Fresh weight ( g / plant ) leaves | branches | total | Dry weight ( g / plant ) leaves | branches | total |
|---|---|---|---|---|---|---|---|---|---|
| **Kg P2O5/fed.** | | | | | | | | | |
| 0 | 44.00 | 37.20 | 3.70 | 60.34 | 21.19 | 81.53 | 8.35 | 3.73 | 12.08 |
| 64 | 45.10 | 39.80 | 4.20 | 65.26 | 25.67 | 90.93 | 9.65 | 4.15 | 13.80 |
| 80 | 45.90 | 35.30 | 3.70 | 69.49 | 29.49 | 98.98 | 10.91 | 4.42 | 15.33 |
| 96 | 44.30 | 36.30 | 3.50 | 56.78 | 28.11 | 84.89 | 9.62 | 4.16 | 13.78 |
| **L.S.D. at 0.05** | **N.S.** | **N.S.** | **N.S.** | **1.40** | **1.07** | **2.53** | **N.S.** | **N.S.** | **0.80** |
| **Kg N/fed.** | | | | | | | | | |
| 0 | 44.15 | 33.50 | 3.60 | 54.74 | 22.61 | 77.35 | 9.27 | 3.66 | 12.93 |
| 120 | 46.60 | 39.30 | 3.50 | 63.66 | 28.02 | 91.68 | 11.98 | 4.31 | 16.29 |
| 180 | 45.40 | 40.10 | 3.80 | 72.18 | 32.24 | 104.42 | 13.08 | 5.25 | 18.33 |
| 240 | 42.40 | 39.30 | 4.00 | 67.86 | 25.66 | 93.52 | 11.33 | 3.87 | 15.20 |
| 300 | 45.80 | 33.60 | 3.80 | 56.40 | 22.04 | 78.44 | 9.76 | 3.49 | 13.25 |
| **L.S.D. at 0.05** | **N.S.** | **N.S.** | **N.S.** | **3.17** | **2.46** | **3.92** | **1.54** | **1.05** | **2.03** |

**Table (34): Vegetative growth of tomato plants, at flowering stage ( 50 days after transplanting ) as affected by nitrogen within phosphorus fertilization during early summer season of 1993.**

**Early summer season, 1993**

| Treatments | | Plant ht. | No. of leaves | No. of branches | Fresh weight ( g / plant ) | | | Dry weight ( g / plant ) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Kg S/fed. | Kg P2O5/fed. | Cm. | / plant | / plant | leaves | branches | total | leaves | branches | total |
| 0 | 0 | 39.30 | 13.60 | 1.80 | 9.60 | 6.34 | 15.94 | 2.27 | 0.79 | 3.06 |
| | 120 | 39.60 | 14.50 | 1.30 | 12.62 | 8.32 | 20.94 | 2.72 | 1.15 | 3.87 |
| | 180 | 37.00 | 15.80 | 2.80 | 14.96 | 7.28 | 22.24 | 3.07 | 0.96 | 4.03 |
| | 240 | 49.50 | 12.10 | 1.60 | 11.77 | 5.08 | 16.85 | 2.36 | 0.65 | 3.01 |
| | 300 | 39.10 | 12.30 | 1.50 | 10.52 | 5.12 | 15.64 | 2.31 | 0.63 | 2.94 |
| 64 | 0 | 39.00 | 13.10 | 1.60 | 11.25 | 5.76 | 17.01 | 2.22 | 0.88 | 3.10 |
| | 120 | 40.60 | 15.30 | 1.60 | 13.74 | 6.41 | 20.15 | 2.65 | 1.07 | 3.72 |
| | 180 | 39.80 | 16.80 | 2.60 | 18.14 | 8.15 | 26.29 | 3.11 | 1.02 | 4.13 |
| | 240 | 42.80 | 13.50 | 1.83 | 16.12 | 5.18 | 21.30 | 2.42 | 0.84 | 3.26 |
| | 300 | 36.50 | 13.50 | 2.50 | 12.87 | 5.45 | 18.32 | 2.48 | 0.83 | 3.31 |
| 80 | 0 | 40.60 | 12.80 | 1.50 | 10.99 | 5.58 | 16.57 | 1.80 | 0.73 | 2.53 |
| | 120 | 36.00 | 14.00 | 1.80 | 14.71 | 6.30 | 21.01 | 2.42 | 0.99 | 3.41 |
| | 180 | 38.50 | 15.10 | 1.50 | 14.45 | 7.51 | 21.96 | 2.59 | 1.30 | 3.89 |
| | 240 | 36.70 | 13.70 | 1.60 | 12.77 | 4.81 | 17.58 | 2.20 | 0.83 | 3.03 |
| | 300 | 37.20 | 13.10 | 1.50 | 12.34 | 4.31 | 16.65 | 2.04 | 0.80 | 2.84 |
| 96 | 0 | 40.10 | 13.00 | 1.60 | 13.64 | 6.47 | 20.11 | 2.18 | 0.95 | 3.13 |
| | 120 | 38.60 | 15.60 | 2.00 | 15.78 | 7.54 | 23.32 | 3.19 | 1.20 | 4.39 |
| | 180 | 40.30 | 13.60 | 1.60 | 14.23 | 5.55 | 19.78 | 2.70 | 0.77 | 3.47 |
| | 240 | 38.00 | 13.60 | 2.00 | 11.19 | 4.65 | 15.84 | 2.03 | 0.66 | 2.69 |
| | 300 | 36.70 | 12.60 | 1.50 | 10.43 | 4.89 | 15.32 | 2.09 | 0.79 | 2.88 |
| **L.S.D. at 0.05** | | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** |

**Table (35): Vegetative growth of tomato plants, at flowering stage ( 50 days after transplanting ) as affected by nitrogen within phosphorus fertilization during early summer season of 1994.**

**Early summer season, 1994**

| Treatments | | Plant ht. | No. of leaves | No. of branches | Fresh weight ( g / plant ) | | | Dry weight ( g / plant ) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Kg S/fed. | Kg P2O5/fed. | Cm. | / plant | / plant | leaves | branches | total | leaves | branches | total |
| 0 | 0 | 38.50 | 30.30 | 3.16 | 55.49 | 18.46 | 73.95 | 8.99 | 3.64 | 12.63 |
| | 120 | 45.00 | 38.10 | 4.30 | 68.12 | 28.00 | 96.12 | 14.28 | 4.56 | 18.84 |
| | 180 | 44.10 | 42.50 | 3.50 | 60.62 | 20.76 | 81.38 | 12.24 | 3.76 | 16.00 |
| | 240 | 50.30 | 37.80 | 3.00 | 58.60 | 19.76 | 78.36 | 11.10 | 3.34 | 14.44 |
| | 300 | 42.10 | 37.50 | 4.80 | 58.88 | 19.01 | 77.89 | 11.14 | 3.38 | 14.52 |
| 64 | 0 | 43.50 | 38.60 | 5.10 | 62.97 | 23.56 | 86.53 | 10.26 | 3.71 | 13.97 |
| | 120 | 45.00 | 39.30 | 2.60 | 61.73 | 24.16 | 85.89 | 11.50 | 4.05 | 15.55 |
| | 180 | 46.80 | 41.80 | 4.50 | 72.56 | 30.23 | 102.79 | 14.23 | 5.52 | 19.75 |
| | 240 | 43.00 | 45.00 | 4.60 | 68.41 | 26.05 | 94.46 | 11.36 | 3.89 | 15.25 |
| | 300 | 47.50 | 34.50 | 4.10 | 60.67 | 24.35 | 85.02 | 10.90 | 3.62 | 14.52 |
| 80 | 0 | 45.80 | 27.10 | 2.60 | 50.22 | 24.17 | 74.39 | 8.93 | 3.42 | 12.35 |
| | 120 | 46.10 | 34.60 | 3.80 | 68.71 | 27.65 | 96.36 | 10.76 | 4.12 | 14.88 |
| | 180 | 50.30 | 41.50 | 4.00 | 91.42 | 40.82 | 132.24 | 14.42 | 6.21 | 20.63 |
| | 240 | 41.50 | 41.10 | 4.60 | 84.26 | 30.67 | 114.93 | 12.61 | 4.58 | 17.19 |
| | 300 | 46.10 | 32.60 | 3.60 | 52.87 | 24.17 | 77.04 | 7.87 | 3.78 | 11.65 |
| 96 | 0 | 48.80 | 38.30 | 3.80 | 50.29 | 24.28 | 74.57 | 8.92 | 3.89 | 12.81 |
| | 120 | 50.30 | 45.30 | 3.50 | 56.09 | 32.27 | 88.36 | 9.38 | 4.51 | 13.89 |
| | 180 | 40.50 | 34.80 | 3.30 | 64.14 | 37.17 | 101.31 | 10.43 | 5.53 | 15.96 |
| | 240 | 43.80 | 33.30 | 4.00 | 60.19 | 26.17 | 86.36 | 10.25 | 3.67 | 13.92 |
| | 300 | 47.50 | 30.10 | 3.00 | 53.19 | 20.66 | 73.85 | 9.15 | 3.20 | 12.35 |
| **L.S.D. at 0.05** | | **7.40** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** |

Table (36): Vegetative growth of tomato plants, at fruit set stage ( 70 days after transplanting ) as affected by nitrogen and phosphorus application, during early summer seasons of 1993 and 1994.

## Early summer season, 1993

| Treatments | Plant ht Cm. | No. of leaves / plant | No. of branches / plant | Fresh weight ( g / plant ) | | | Dry weight ( g / plant ) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | leaves | branches | total | leaves | branches | total |
| **Kg P2O5/fed.** | | | | | | | | | |
| 0 | 69.40 | 26.00 | 3.40 | 47.58 | 25.72 | 73.30 | 10.19 | 3.35 | 13.54 |
| 64 | 67.50 | 27.50 | 3.70 | 57.71 | 24.75 | 82.46 | 10.32 | 3.86 | 14.18 |
| 80 | 64.20 | 26.10 | 2.90 | 52.23 | 22.82 | 75.05 | 8.85 | 3.69 | 12.54 |
| 96 | 65.80 | 26.00 | 3.20 | 52.22 | 23.29 | 75.51 | 9.77 | 3.50 | 13.27 |
| **L.S.D. at 0.05** | **N.S.** | **N.S.** | **N.S.** | **0.93** | **N.S.** | **2.01** | **0.30** | **N.S.** | **0.42** |
| **Kg N/fed.** | | | | | | | | | |
| 0 | 57.50 | 25.00 | 3.00 | 45.48 | 23.41 | 68.89 | 8.48 | 3.36 | 11.84 |
| 120 | 65.70 | 28.20 | 3.20 | 56.85 | 28.57 | 85.41 | 10.99 | 4.42 | 15.41 |
| 180 | 66.00 | 29.10 | 3.90 | 61.80 | 28.49 | 90.29 | 11.48 | 4.23 | 15.71 |
| 240 | 71.10 | 25.20 | 3.30 | 51.86 | 19.71 | 71.57 | 9.02 | 2.98 | 12.00 |
| 300 | 63.40 | 24.50 | 3.20 | 46.18 | 19.78 | 65.96 | 8.93 | 3.01 | 11.94 |
| **L.S.D. at 0.05** | **2.01** | **N.S.** | **N.S.** | **2.73** | **1.46** | **3.23** | **1.05** | **N.S** | **2.17** |

## Early summer season, 1994

| Treatments | Plant ht Cm. | No. of leaves / plant | No. of branches / plant | Fresh weight ( g / plant ) | | | Dry weight ( g / plant ) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | leaves | branches | total | leaves | branches | total |
| **Kg P2O5/fed.** | | | | | | | | | |
| 0 | 56.70 | 60.02 | 5.90 | 111.28 | 81.53 | 192.81 | 21.33 | 15.19 | 36.52 |
| 64 | 58.80 | 64.20 | 6.40 | 120.15 | 105.23 | 225.38 | 22.86 | 17.18 | 40.04 |
| 80 | 59.70 | 58.10 | 5.90 | 127.69 | 120.10 | 247.79 | 22.44 | 18.02 | 40.46 |
| 96 | 58.30 | 59.70 | 5.30 | 104.80 | 115.12 | 219.92 | 19.15 | 17.12 | 36.27 |
| **L.S.D. at 0.05** | **N.S.** | **N.S.** | **N.S.** | 3.42 | **4.05** | **5.82** | **N.S.** | **1.03** | 0.37 |
| **Kg N/fed.** | | | | | | | | | |
| 0 | 57.40 | 53.70 | 5.20 | 100.20 | 91.22 | 191.42 | 18.85 | 14.50 | 33.35 |
| 120 | 61.30 | 64.80 | 6.10 | 118.42 | 168.80 | 230.78 | 24.09 | 18.24 | 42.33 |
| 180 | 58.80 | 65.10 | 6.10 | 132.51 | 132.03 | 264.54 | 26.17 | 21.74 | 47.91 |
| 240 | 54.90 | 63.30 | 6.40 | 124.40 | 103.83 | 228.23 | 21.77 | 15.74 | 37.51 |
| 300 | 59.50 | 55.50 | 5.60 | 104.35 | 88.03 | 192.38 | 19.84 | 14.16 | 34.00 |
| **L.S.D. at 0.05** | **N.S.** | **3.21** | **N.S.** | **4.25** | **3.07** | **6.24** | **1.08** | **3.01** | **3.76** |

**Table (37): Vegetative growth of tomato plants, at fruit set stage ( 70 days after transplanting ) as affected by nitrogen within phosphorus fertilization, during early summer season of 1993.**

**Early summer season, 1993**

| Treatments | | Plant ht. | No. of leaves | No. of branches | Fresh weight ( g / plant ) | | | Dry weight ( g / plant ) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Kg S/fed. | Kg P2O5/fed. | Cm. | / plant | / plant | leaves | branche | total | leaves | branches | total |
| 0 | 0 | 66.80 | 25.80 | 3.40 | 38.40 | 25.36 | 63.76 | 9.08 | 3.16 | 12.24 |
| | 120 | 67.00 | 27.50 | 2.50 | 50.50 | 33.30 | 83.80 | 10.90 | 4.62 | 15.52 |
| | 180 | 62.80 | 30.00 | 5.20 | 59.86 | 29.13 | 88.99 | 12.29 | 3.84 | 16.13 |
| | 240 | 84.30 | 23.30 | 3.10 | 47.08 | 20.32 | 67.40 | 9.44 | 2.62 | 12.06 |
| | 300 | 66.40 | 23.50 | 2.80 | 42.09 | 20.50 | 62.59 | 9.24 | 2.54 | 11.78 |
| 64 | 0 | 66.20 | 25.20 | 2.90 | 45.00 | 23.05 | 68.05 | 8.89 | 3.53 | 12.42 |
| | 120 | 69.00 | 29.00 | 3.20 | 54.96 | 25.65 | 80.61 | 10.61 | 4.29 | 14.90 |
| | 180 | 67.60 | 32.00 | 4.50 | 72.58 | 32.61 | 105.19 | 12.46 | 4.82 | 17.28 |
| | 240 | 72.80 | 25.60 | 3.40 | 64.50 | 20.66 | 85.16 | 9.70 | 3.37 | 13.07 |
| | 300 | 61.90 | 25.60 | 4.70 | 51.51 | 21.80 | 73.31 | 9.94 | 3.32 | 13.26 |
| 80 | 0 | 69.00 | 24.50 | 2.80 | 43.99 | 22.34 | 66.33 | 7.22 | 2.93 | 10.15 |
| | 120 | 61.10 | 26.50 | 3.40 | 58.84 | 25.20 | 84.04 | 9.69 | 3.97 | 13.66 |
| | 180 | 65.20 | 28.70 | 2.80 | 57.84 | 30.05 | 87.89 | 10.37 | 5.21 | 15.58 |
| | 240 | 62.50 | 25.90 | 3.10 | 51.09 | 19.26 | 70.35 | 8.81 | 3.32 | 12.13 |
| | 300 | 63.10 | 25.00 | 2.80 | 49.40 | 17.26 | 66.66 | 8.17 | 3.02 | 11.19 |
| 96 | 0 | 68.20 | 24.60 | 3.00 | 54.56 | 25.90 | 80.46 | 8.73 | 3.82 | 12.55 |
| | 120 | 65.70 | 29.70 | 3.80 | 63.13 | 30.16 | 93.29 | 12.78 | 4.80 | 17.58 |
| | 180 | 68.50 | 25.90 | 3.10 | 56.93 | 22.20 | 79.13 | 10.82 | 3.08 | 13.90 |
| | 240 | 64.70 | 25.90 | 3.70 | 44.77 | 18.62 | 63.39 | 8.14 | 2.64 | 10.78 |
| | 300 | 62.20 | 24.00 | 2.70 | 41.74 | 19.57 | 61.31 | 8.38 | 3.16 | 11.54 |
| L.S.D. at 0.05 | | N.S. | N.S. | 1.52 | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. |

**Table (38): Vegetative growth of tomato plants, at fruit set stage ( 70 days after transplanting ) as affected by nitrogen within phosphorus fertilization, during early summer season of 1994.**

**Early summer season, 1994**

| Treatments | | Plant ht. | No. of leaves | No. of branches | Fresh weight ( g / plant ) | | | Dry weight ( g / plant ) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Kg S/fed. | Kg P2O5/fed. | Cm. | / plant | / plant | leaves | branche | total | leaves | branches | total |
| 0 | 0 | 50.70 | 48.40 | 5.10 | 101.88 | 70.15 | 172.03 | 18.65 | 14.57 | 33.22 |
| | 120 | 58.40 | 62.60 | 6.90 | 125.95 | 109.75 | 235.70 | 30.60 | 19.24 | 49.84 |
| | 180 | 56.10 | 68.60 | 6.20 | 112.45 | 80.56 | 193.01 | 27.15 | 15.24 | 42.39 |
| | 240 | 63.70 | 60.50 | 5.10 | 108.82 | 75.08 | 183.90 | 21.09 | 13.37 | 34.46 |
| | 300 | 54.60 | 60.00 | 6.30 | 107.32 | 72.13 | 179.45 | 21.17 | 13.54 | 34.71 |
| 64 | 0 | 56.50 | 61.80 | 5.60 | 113.01 | 97.60 | 210.61 | 20.49 | 15.17 | 35.66 |
| | 120 | 59.30 | 64.60 | 6.30 | 116.12 | 100.00 | 216.12 | 23.52 | 16.89 | 40.41 |
| | 180 | 60.80 | 67.90 | 6.50 | 132.61 | 124.92 | 257.53 | 27.69 | 23.44 | 51.13 |
| | 240 | 55.80 | 71.90 | 7.10 | 126.47 | 106.22 | 232.69 | 21.92 | 15.92 | 37.84 |
| | 300 | 61.60 | 55.10 | 6.40 | 112.54 | 97.41 | 209.95 | 20.70 | 14.50 | 35.20 |
| 80 | 0 | 59.00 | 43.40 | 4.90 | 93.74 | 100.02 | 193.76 | 18.64 | 14.36 | 33.00 |
| | 120 | 61.20 | 58.10 | 5.50 | 127.34 | 110.61 | 237.95 | 21.78 | 16.48 | 38.26 |
| | 180 | 64.40 | 67.10 | 6.40 | 166.22 | 167.28 | 333.50 | 28.06 | 25.50 | 53.56 |
| | 240 | 53.90 | 66.50 | 7.40 | 152.67 | 126.01 | 278.68 | 24.63 | 18.65 | 43.28 |
| | 300 | 60.10 | 55.60 | 5.40 | 98.50 | 96.62 | 195.12 | 19.12 | 15.14 | 34.26 |
| 96 | 0 | 63.40 | 61.30 | 5.20 | 92.18 | 97.14 | 189.32 | 17.62 | 13.92 | 31.54 |
| | 120 | 66.40 | 74.20 | 5.60 | 104.30 | 129.09 | 233.39 | 18.48 | 20.38 | 38.86 |
| | 180 | 53.90 | 57.00 | 5.30 | 118.78 | 155.36 | 274.14 | 21.81 | 22.80 | 44.61 |
| | 240 | 46.20 | 54.60 | 6.10 | 109.67 | 108.04 | 217.71 | 19.47 | 15.04 | 34.51 |
| | 300 | 61.70 | 51.60 | 4.30 | 99.07 | 85.97 | 185.04 | 18.38 | 13.49 | 31.87 |
| L.S.D. at 0.05 | | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. |

## 4.3.2. Effect of nitrogen and/or phosphorus on tomato fruit yield and its components.

The main effect of phosphorus or nitrogen on tomato fruit yield have been discussed in the first and second experiments of this thesis. Data in Table (39) showed the same trend and indicated that 64 Kg $P_2O_5$/fed. gave the highest early marketable and total yield as ton/fed. This trend was true in both seasons. Moreover, heavy P-application at 80 or 96 Kg $P_2O_5$/fed. did not increase either early, marketable or total yield production of tomato. These results are in agreement with Bhatangar and Pandita (1979); Abdalla et al (1979); Ramakrishma and Sulladmath(1979) and Gibson and Pill (1983) as previously mentioned in the second experiment under ( 4.2.3. ).

With respect to the main effect of N-fertilizer data in Table (39) showed that 120 Kg N/fed. was the best level for early, marketable and total yield production as ton/fed. However, heavy N-application up to 240 or 300 Kg N/fed. decreased early, marketable and total yield of tomato. This favorable effect of moderate level of N-application is in agreement with the results of Anand and Muthurishnan(1974/a); Doss et al (1975); Oswiecimski (1981); Kooner and Randhawa (1983) and EL-Aela (1988). Moreover, the adverse effect of heavy N-application on early, marketable and total yield production are in harmony with Doss et al (1975) and EL-Aela (1988). The explanation of these results have been discussed before in the first experiment of this thesis ( 4.1.3. ).

**Table (39): Tomato fruit yield and its components as affected by nitrogen and phosphorus during the seasons of 1993 and 1994.**

**Early summer season, 1993**

| Treatments | Early yield ton/fed. | Marketable yield ton/fed. | Total yield ton/fed. |
|---|---|---|---|
| **Kg P2O5/fed.** | | | |
| 0 | 3.04 | 7.38 | 7.80 |
| 64 | 3.32 | 7.88 | 8.33 |
| 80 | 3.30 | 7.60 | 8.02 |
| 96 | 3.07 | 7.45 | 7.79 |
| **L.S.D. at 0.05** | **0.11** | **0.21** | **0.42** |
| **Kg N/fed.** | | | |
| 0 | 3.01 | 7.17 | 7.51 |
| 120 | 3.48 | 8.03 | 8.49 |
| 180 | 3.28 | 7.65 | 8.10 |
| 240 | 3.16 | 7.54 | 7.92 |
| 300 | 2.90 | 7.52 | 7.90 |
| **L.S.D. at 0.05** | **0.02** | **0.42** | **0.48** |

**Early summer season, 1994**

| Treatments | Early yield ton/fed. | Marketable yield ton/fed. | Total yield ton/fed. |
|---|---|---|---|
| **Kg P2O5/fed.** | | | |
| 0 | 3.81 | 7.81 | 10.87 |
| 64 | 4.27 | 9.30 | 12.33 |
| 80 | 4.03 | 8.11 | 10.46 |
| 96 | 4.12 | 8.35 | 10.79 |
| **L.S.D. at 0.05** | **0.20** | **0.92** | **1.04** |
| **Kg N/fed.** | | | |
| 0 | 3.10 | 6.74 | 8.76 |
| 120 | 4.53 | 9.64 | 12.60 |
| 180 | 4.84 | 9.54 | 12.89 |
| 240 | 4.58 | 8.92 | 11.83 |
| 300 | 3.97 | 7.12 | 9.50 |
| **L.S.D. at 0.05** | **0.93** | **0.84** | **1.03** |

Concerning the interaction effect between nitrogen and phosphorus on fruit yield and its components, data in Tables (40 & 41) showed that the highest early yield of tomato was obtained when plant fertilized with 120 Kg N + 64 or 80 Kg $P_2O_5$/fed. or 180 Kg N + 64 Kg $P_2O_5$/fed. with no significant differences between these three treatments as shown in the first season. Data of the second season also showed that plants received moderate levels of nitrogen within moderate or high P-level; 120 or 180 Kg N/fed. + 64 or 96 Kg $P_2O_5$/fed. gave the highest early yield.

As a general trend for both seasons 180 Kg N + 64 Kg $P_2O_5$, 180 Kg N + 96 Kg $P_2O_5$ followed by 240 Kg N + 96 Kg $P_2O_5$/fed. proved to be the most favorable treatments on increasing early yield production. Since, all treatments received 48 Kg $K_2O$/fed it means that the most favorable analysis of N : P : K fertilizer were;

180 Kg N : 64 Kg $P_2O_5$ : 48 Kg $K_2O$/fed = ratio of 3.7 :1.3 : 1 NPK
180 Kg N : 96 Kg $P_2O_5$ : 48 Kg $K_2O$ /fed. = ratio of 3.7 : 2 : 1 NPK
240 Kg N : 96 Kg $P_2O_5$ : 48 kg $K_2O$ /fed. = ratio of 5 : 2 : 1 NPK

It could be concluded from the previous data of early yield that moderate levels of N and P; 180-240 Kg N/fed. + 64 Kg $P_2O_5$/fed are recommended to get the highest early yield under field conditions of this experiment; clay loam soil with pH 8.15 . These results are in harmony with Sulikeri et al (1975) and Jaramillo et al (1978) they recommended a moderate level of N and P for high early yield production.

**Table (40): Tomato fruit yield and its components as affected by nitorgen within phosphorus during the season of 1993.**

**Early summer season, 1993**

| Treatments Kg P2O5/fed. | Kg N/fed. | Early yield ton/fed. | Marketable yield ton/fed. | Total yield ton/fed. |
|---|---|---|---|---|
| 0 | 0 | 3.09 | 6.99 | 7.31 |
| | 120 | 3.67 | 8.09 | 8.63 |
| | 180 | 3.41 | 7.57 | 8.03 |
| | 240 | 3.11 | 7.49 | 7.87 |
| | 300 | 1.92 | 6.76 | 7.15 |
| 64 | 0 | 3.49 | 7.71 | 8.15 |
| | 120 | 3.64 | 8.71 | 9.17 |
| | 180 | 3.57 | 8.01 | 8.51 |
| | 240 | 2.77 | 7.20 | 7.59 |
| | 300 | 3.12 | 7.79 | 8.24 |
| 80 | 0 | 3.17 | 7.29 | 7.65 |
| | 120 | 3.67 | 7.97 | 8.43 |
| | 180 | 3.05 | 7.36 | 7.86 |
| | 240 | 3.42 | 7.60 | 7.98 |
| | 300 | 3.18 | 7.78 | 8.17 |
| 96 | 0 | 2.61 | 6.68 | 6.93 |
| | 120 | 2.93 | 7.33 | 7.73 |
| | 180 | 3.09 | 7.65 | 7.99 |
| | 240 | 3.32 | 7.85 | 8.22 |
| | 300 | 3.37 | 7.73 | 8.06 |
| **L.S.D. at 0.05** | | **0.23** | **0.49** | **0.43** |

**Table (41): Tomato fruit yield and its components as affected by nitorgen within phosphorus during the season of 1994.**

**Early summer season, 1994**

| Treatments Kg P2O5/fed. | Kg N/fed. | Early yield ton/fed. | Marketable yield ton/fed. | Total yield ton/fed. |
|---|---|---|---|---|
| | 0 | 1.47 | 7.29 | 8.95 |
| | 120 | 4.42 | 8.69 | 12.49 |
| 0 | 180 | 4.13 | 8.07 | 12.13 |
| | 240 | 4.90 | 8.03 | 11.16 |
| | 300 | 4.13 | 6.97 | 9.91 |
| | 0 | 4.42 | 8.08 | 9.81 |
| | 120 | 4.22 | 10.84 | 14.29 |
| 64 | 180 | 4.53 | 9.78 | 13.38 |
| | 240 | 4.69 | 9.82 | 13.46 |
| | 300 | 3.52 | 7.99 | 10.73 |
| | 0 | 2.16 | 5.60 | 7.40 |
| | 120 | 4.21 | 8.98 | 11.32 |
| 80 | 180 | 5.08 | 9.69 | 13.23 |
| | 240 | 4.25 | 9.44 | 11.50 |
| | 300 | 3.46 | 6.81 | 8.88 |
| | 0 | 2.32 | 6.01 | 8.87 |
| | 120 | 5.26 | 10.03 | 12.56 |
| 96 | 180 | 5.60 | 10.63 | 12.83 |
| | 240 | 4.46 | 8.39 | 11.19 |
| | 300 | 2.96 | 6.70 | 8.50 |
| **L.S.D. at 0.05** | | **0.36** | **0.87** | **0.71** |

As for marketable and total yield production, data in Tables (40 & 41) showed that the highest marketable and total yield were obtained from plants supplied with 120 Kg N + 64 Kg $P_2O_5$/fed. followed by those received 180 Kg N + 64 Kg $P_2O_5$/fed. as a general trend for both seasons. Increasing level of N-application at 300 Kg N + 64 Kg $P_2O_5$/fed. or at 240 Kg N + 96 Kg $P_2O_5$/fed.( in the first season ) and 240 Kg N+ 64 Kg $P_2O_5$/fed.( in the second season ) significantly increased fruit total yield as compared with other treatments received higher levels of P or N. These results could be attributed to the balance between N: P: K fertilizers used here were as follows:

120 Kg N : 64 Kg $P_2O_5$ : 48 Kg $K_2O$ /fed. = ratio of 1.8 : 1: 0.75
180 Kg N : 64 Kg $P_2O_5$ : 48 Kg $K_2O$ /fed. = ratio of 2.8 : 1: 0.75

The first level of 120 Kg N : 64 Kg $P_2O_5$ : 48 Kg $K_2O$ /fed. have been recommended as the best level for tomato production by the Egyptian Ministry of Agriculture .This result may be due to that the moderate level of nitrogen and phosphorus application gave a higher vegetative growth and mineral content of tomato plant foliage as mentioned in the first and second experiments in this research. The favorable effect of moderate N and P application on marketable and total yield have been mentioned by Leela et al (1973); Yanatev and Zharikova(1975) and Gupta and Shukla (1977). Moreover, Bhatnagar and Pandita (1979) found that the highest tomato fruit yield was obtained with 80 Kg N and 60 Kg $P_2O_5$/ha. compared with other treatments supplied with 40 to 120 Kg N in combination with 30 to 90 Kg $P_2O_5$/ha.

On the other hand, plants with no N-application had a low total yield, moreover, plants received high levels of N (300 Kg N/fed.) within 0 or 96 Kg $P_2O_5$/fed. also had the lower total yield production. This result could be referred to the vital role of N-application on plant growth, mineral content, fruit setting and fruit development and consequently total fruit yield as well as number of fruits per plant. Therefore, plants received no N-fertilizer ( control ) is expected to show symptoms of N-deficiency with low yield production . Moreover, heavy N-application at 300 Kg N/fed. decreased plant growth, early and total yield production. This result may be due to the unbalance between N and P i.e. plants received 300 Kg N + 80 or 96 Kg $P_2O_5$ + 48 Kg $K_2O$ /fed. mean a fertilizer ratio of N : P : K equal to 6 : 2 : 1 approximately. Moreover, the effect C / N ratio of tomato plant tissue on fruit setting should be taken in consideration.

***As a final conclusion ; 120 Kg N +64 Kg $P_2O_5$/fed. was the best level of nitrogen within phosphorus fertilization to get the highest early, marketable and total yield of tomato fruit .***

### 4.3.3. Effect of nitrogen and/or phosphorus fertilization on tomato fruit quality.

With respect to the main effect of N-application on tomato fruit quality, data in Table (42) showed that fruit diminution, fruit dry weight % and TSS% were not significantly affected by N-level application in both seasons. Average fruit weight was significantly increased by increasing level of N-application up to 180 Kg N/fed. and then decreased again. Vitamin-C content was significantly increased by increasing level of N-application up to 120 or 180 Kg N/fed. in the first and second season respectively. Total acidity was increased significantly by increasing level of N-application up to 180 or 240 Kg N/fed. in the first and second season respectively, but the highest level of N-application decreased total acidity in both seasons. $NO_3$-N accumulation was gradually and significantly increased by increasing level of N-application in both seasons. These results have been discussed in ( 4.1.4. ) in the first experiment.

**Table (42): Tomato fruit quality as affected by nitrogen and phosphorus application during the seasons of 1993 and 1994.**

**Early summer season, 1993**

| Treatments | Fruit L. Cm. | Fruit D. Cm. | Fruit W. g/fruit | Fruit dry W. % | T.S.S. % | Total acidity mg/l. | Vitamin C mg/100cm3 | NO3-N ppm |
|---|---|---|---|---|---|---|---|---|
| **Kg P2O5/fed.** | | | | | | | | |
| 0 | 5.20 | 5.48 | 84.34 | 4.58 | 4.18 | 655.10 | 20.86 | 22.82 |
| 64 | 5.12 | 5.34 | 90.90 | 4.60 | 3.98 | 701.10 | 21.82 | 21.58 |
| 80 | 5.14 | 5.40 | 91.08 | 4.52 | 4.12 | 697.90 | 21.60 | 20.84 |
| 96 | 5.12 | 5.34 | 90.62 | 4.45 | 4.08 | 706.20 | 21.50 | 18.04 |
| **L.S.D. at 0.05** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **21.80** | **N.S.** | **2.15** |
| **Kg N/fed.** | | | | | | | | |
| 0 | 5.15 | 5.37 | 87.00 | 4.37 | 4.15 | 649.20 | 20.25 | 1.00 |
| 120 | 5.05 | 5.45 | 87.50 | 4.63 | 4.20 | 657.20 | 21.62 | 18.40 |
| 180 | 5.17 | 5.22 | 92.00 | 4.46 | 4.02 | 718.70 | 22.12 | 24.60 |
| 240 | 5.07 | 5.40 | 91.10 | 4.68 | 4.05 | 731.80 | 21.87 | 28.60 |
| 300 | 5.27 | 5.50 | 88.60 | 4.56 | 4.02 | 704.70 | 21.35 | 31.30 |
| **L.S.D. at 0.05** | **N.S.** | **N.S.** | **2.10** | **N.S.** | **N.S.** | **24.50** | **0.84** | **2.01** |

**Early summer season, 1994**

| Treatments | Fruit L. Cm. | Fruit D. Cm. | Fruit W. g/fruit | Fruit dry W. % | T.S.S. % | Total acidity mg/l. | Vitamin C mg/100cm3 | NO3-N ppm |
|---|---|---|---|---|---|---|---|---|
| **Kg P2O5/fed.** | | | | | | | | |
| 0 | 5.38 | 5.68 | 85.60 | 4.60 | 3.66 | 684.40 | 21.40 | 20.70 |
| 64 | 5.32 | 5.62 | 91.90 | 4.64 | 3.90 | 735.90 | 22.30 | 20.60 |
| 80 | 5.48 | 5.54 | 99.20 | 4.62 | 3.78 | 717.90 | 21.80 | 18.70 |
| 96 | 5.50 | 5.60 | 98.30 | 4.65 | 3.80 | 722.30 | 22.30 | 17.64 |
| **L.S.D. at 0.05** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **24.70** | **N.S.** | **1.93** |
| **Kg N/fed.** | | | | | | | | |
| 0 | 5.37 | 5.67 | 91.15 | 4.64 | 3.57 | 673.02 | 20.85 | 1.00 |
| 120 | 5.45 | 5.65 | 93.67 | 4.67 | 3.67 | 673.12 | 21.47 | 16.50 |
| 180 | 5.37 | 5.70 | 96.47 | 4.57 | 3.87 | 738.70 | 22.70 | 22.92 |
| 240 | 5.45 | 5.45 | 93.75 | 4.68 | 3.95 | 765.87 | 23.25 | 26.80 |
| 300 | 5.45 | 5.57 | 93.95 | 4.57 | 3.85 | 725.07 | 21.52 | 29.82 |
| **L.S.D. at 0.05** | **N.S.** | **N.S.** | **1.92** | **N.S.** | **N.S.** | **15.80** | **0.97** | **2.34** |

With respect to the main effect of P-application on tomato fruit quality, data in Table (42) showed that fruit diminution, average fruit weight, fruit dry weight %, TSS and Vitamin-C content were not significantly affected by increasing level of P-application as shown in both seasons. However, total acidity was significantly increased by increasing level of P-application up to 64 Kg $P_2O_5$/fed. with no significant differences between 64, 80 or 96 Kg $P_2O_5$/fed. in both seasons. $NO_3$-N content was gradually and significantly decreased by increasing level of P-application as shown in both seasons. This result may be due to the stimulation role of $HPO_4^{--}$ on N-assimilation and the combitation role of $HPO_4^{--}$ on $NO_3^-$ uptake.

With respect to the effect of nitrogen within phosphorus fertilization on tomato fruit quality, data in Tables (43 & 44) showed that fruit length, diameter, average fruit weight and fruit dry weight % were not significantly affected by any of the used interactional treatments of N within P . These results were true in both seasons. TSS % of tomato fruit also showed the same trend but only in the first season. However, Vitamin -C content in both seasons and TSS% only in the second seasons were imported by most interactional N x P treatments as compared with the control. Adding 64 Kg $P_2O_5$ + 180 or 300 Kg N/fed. or 80 Kg $P_2O_5$ + 120 Kg N/fed. or 96 Kg $P_2O_5$ + 120 or 300 Kg N/fed increased Vitamin-C content of tomato fruit juice.

With respect to total acidity, data showed that the highest value was recorded with 180 Kg N + 64 Kg $P_2O_5$/fed. followed by 240 Kg N + 64 Kg $P_2O_5$/fed. as shown in both seasons, but the lowest value was recorded with 120 Kg N/fed without P-application in the first season and with 80 Kg $P_2O_5$ without N-application in the second season.

**Table (43): Tomato fruit quality as affected by nitrogen within phosphorus during the season of 1993.**

**Early summer season, 1993**

| Treatments | | Fruit L. | Fruit D. | Fruit W. | Fruit dry W. | T.S.S | Total acidity | Vitamin C | NO3-N |
|---|---|---|---|---|---|---|---|---|---|
| N-source | Kg N/fed. | Cm. | Cm. | g/fruit | % | % | mg/l | mg/100cm3 | ppm |
| 0 | 0 | 5.00 | 5.30 | 82.50 | 4.46 | 4.60 | 641.50 | 17.10 | 1.00 |
| | 120 | 5.30 | 5.60 | 84.50 | 4.52 | 4.00 | 602.30 | 20.30 | 19.70 |
| | 180 | 5.40 | 5.50 | 83.20 | 4.75 | 4.20 | 607.00 | 23.00 | 27.80 |
| | 240 | 4.90 | 5.40 | 87.00 | 4.48 | 4.20 | 732.50 | 21.40 | 30.90 |
| | 300 | 5.40 | 5.60 | 84.50 | 4.73 | 3.90 | 692.40 | 22.50 | 34.70 |
| 64 | 0 | 5.30 | 5.50 | 86.40 | 4.63 | 4.00 | 613.80 | 22.60 | 1.00 |
| | 120 | 5.00 | 5.20 | 90.20 | 5.01 | 4.30 | 682.40 | 21.30 | 18.90 |
| | 180 | 5.00 | 5.20 | 93.40 | 4.33 | 3.90 | 813.20 | 22.40 | 25.40 |
| | 240 | 5.30 | 5.40 | 92.50 | 4.74 | 3.70 | 748.10 | 20.10 | 30.10 |
| | 300 | 5.00 | 5.40 | 92.00 | 4.33 | 4.00 | 692.80 | 22.70 | 32.50 |
| 80 | 0 | 5.00 | 5.20 | 86.70 | 4.42 | 4.00 | 613.00 | 20.30 | 1.00 |
| | 120 | 4.70 | 5.50 | 89.20 | 4.47 | 4.20 | 716.20 | 22.40 | 18.40 |
| | 180 | 5.30 | 5.30 | 96.70 | 4.57 | 4.20 | 745.40 | 23.10 | 24.90 |
| | 240 | 5.20 | 5.50 | 92.30 | 4.56 | 4.00 | 708.10 | 22.00 | 28.20 |
| | 300 | 5.50 | 5.50 | 90.50 | 4.60 | 4.20 | 706.90 | 20.20 | 31.70 |
| 96 | 0 | 5.30 | 5.50 | 92.40 | 4.00 | 4.00 | 728.40 | 21.00 | 1.00 |
| | 120 | 5.20 | 5.50 | 86.20 | 4.55 | 4.30 | 627.80 | 22.50 | 16.90 |
| | 180 | 5.00 | 4.90 | 94.70 | 4.20 | 3.80 | 709.40 | 20.00 | 20.30 |
| | 240 | 4.90 | 5.30 | 92.50 | 4.94 | 4.30 | 738.50 | 24.00 | 25.40 |
| | 300 | 5.20 | 5.50 | 87.30 | 4.59 | 4.00 | 726.80 | 20.00 | 26.60 |
| **L.S.D. at 0.05** | | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **7.80** | **2.10** | **2.30** |

**Table (44): Tomato fruit quality as affected by nitrogen within phosphorus during the season of 1994.**

**Early summer season, 1994**

| Treatments | | Fruit L. | Fruit D. | Fruit W. | Fruit dry W. | T.S.S | Total acidity | Vitamin C | NO3-N |
|---|---|---|---|---|---|---|---|---|---|
| N-source | Kg N/fed. | Cm. | Cm. | g/fruit | % | % | mg/l | mg/100cm3 | ppm |
| 0 | 0 | 5.20 | 5.90 | 84.60 | 4.57 | 3.40 | 692.50 | 18.60 | 1.00 |
| | 120 | 5.30 | 5.70 | 86.80 | 4.64 | 3.50 | 620.90 | 22.30 | 18.40 |
| | 180 | 5.50 | 5.70 | 85.70 | 4.52 | 3.80 | 621.00 | 20.40 | 25.80 |
| | 240 | 5.30 | 5.50 | 83.60 | 4.69 | 3.70 | 769.10 | 24.00 | 27.90 |
| | 300 | 5.60 | 5.60 | 87.50 | 4.58 | 3.90 | 718.60 | 21.70 | 30.40 |
| 64 | 0 | 5.20 | 5.80 | 89.40 | 4.74 | 3.80 | 630.20 | 20.50 | 1.00 |
| | 120 | 5.50 | 5.50 | 95.60 | 4.65 | 3.70 | 695.90 | 22.80 | 16.00 |
| | 180 | 5.30 | 5.80 | 98.60 | 4.59 | 4.00 | 854.10 | 24.20 | 24.00 |
| | 240 | 5.40 | 5.50 | 84.30 | 4.62 | 4.20 | 784.70 | 22.40 | 29.70 |
| | 300 | 5.20 | 5.50 | 92.00 | 4.63 | 3.80 | 714.70 | 21.60 | 32.40 |
| 80 | 0 | 5.50 | 5.40 | 93.00 | 4.55 | 3.60 | 610.00 | 22.50 | 1.00 |
| | 120 | 5.60 | 5.70 | 95.00 | 4.64 | 3.80 | 739.20 | 20.80 | 16.20 |
| | 180 | 5.30 | 5.60 | 108.30 | 4.62 | 3.80 | 758.10 | 23.10 | 22.10 |
| | 240 | 5.50 | 5.40 | 104.10 | 4.73 | 4.10 | 753.60 | 22.30 | 25.40 |
| | 300 | 5.50 | 5.60 | 95.70 | 4.58 | 3.60 | 729.00 | 20.70 | 28.70 |
| 96 | 0 | 5.60 | 5.60 | 97.60 | 4.73 | 3.50 | 759.40 | 21.80 | 1.00 |
| | 120 | 5.40 | 5.70 | 97.30 | 4.78 | 3.70 | 636.50 | 20.00 | 15.40 |
| | 180 | 5.40 | 5.70 | 93.30 | 4.55 | 3.90 | 721.60 | 23.10 | 19.80 |
| | 240 | 5.60 | 5.40 | 103.00 | 4.71 | 3.80 | 756.10 | 24.30 | 24.20 |
| | 300 | 5.50 | 5.60 | 100.60 | 4.51 | 4.10 | 738.00 | 22.10 | 27.80 |
| **L.S.D. at 0.05** | | **N.S.** | **N.S.** | **N.S.** | **N.S.** | **0.40** | **10.70** | **3.20** | **2.70** |

As for $NO_3$-N accumulation in tomato fruit, data showed that the highest value were recorded with application of the highest N-level; 300 Kg N + 80 or 96 Kg $P_2O_5$ /fed. and the lowest value was recorded with no N-application within all levels of P-application as shown in both seasons. Data also showed that $NO_3$-N accumulation was gradually increased with increasing level of N-application within all levels of P- application.

This result could be referred to the high accumulation of $NO_3$-N in plant tissues as a result of increasing level of N-fertilizer to soil which increased the available $NO_3$- content of soil extract. This result agree with those of Hargitai and Vass (1976); Miyazaki and Kunisato (1975) and Magalhaes and Wilcox (1984)on tomato and Gabal (1983) on sweet pepper, all revealed that plants accumulate more $NO_3$-N according to incresing level of N-application.