

Growth and Development of Beet Seedlings Cultured  
in Media of Different Levels of N and P Ions.

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**Abstract:** Studies were made to elucidate the effect of varying N/P ratios in the culture media on growth, uptake and accumulation of nutrient ions, and assimilation of nitrate. Increasing nitrate or phosphate ion concentration and keeping the concentration of other ions constant in the culture media, resulted in increased growth accompanied by increased uptake and accumulation of nutrient ions in the seedlings except Ca and  $\text{NO}_3$  ions. The assimilation of nitrate ions also increased.

The stimulation of all these processes were more enhanced with nitrate than with phosphate concentrations although the concentration of  $\text{PO}_4$  ion was much higher than that of  $\text{NO}_3$  ion in the culture media.

### Introduction

The effect of different concentrations of N and P in the nutritive media on growth and metabolism of several plants have been studied by many workers. Thus Cole et al. (1963), studying the effects of N on P uptake and metabolism of corn seedlings, suggested a connection between P uptake and N metabolism, and they were of the opinion that the increase in P uptake rates may reflect higher levels on N-intermediates. Nosseir and Spiridinov (1965) found that the progressive increase of N over P concentration in the nutritive media of Phaseolus seedlings stimulated the uptake of  $P_{32}$  as well as N-metabolism of seedlings. Also Nosseir and Hathout (1970) found that increases in N concentration in the culture media of sweet potato tuber discs stimulated the rate of P uptake. Dumbroff and Michel (1967) found that increasing of P in the nutritive media of pine seedlings stimulated the uptake of N and other ions with simultaneous increases in growth and development and that such increases were dependent on the increases of N and P levels in the nutritive media.

Truog et al. (1947) and Nosseir (1972) found a positive correlation between P and Mg contents of pea seedlings under different nutritional conditions, thus

supporting the theory that Mg serves as carrier of P within the plant. In contrast, Dumbroff and Michel (1967) found no relationship between Mg and P uptake and accumulation in pine seedlings.

The purpose of the present study was to determine the effect of different levels of N and P in the nutritive media on some physiological activities, viz., growth, uptake and accumulation of nutrient elements.

#### Materials and Methods

Seeds of beet ( Beta vulgaris cultivar "Bettrave") were provided by the Ministry of Agriculture, Egypt. Seven lots of beet seed batches were used, each of which were washed in running water for 8 hr, rinsed in 70% ethyl alcohol for surface sterilization (Hatata et al. 1979) washed several times with sterile distilled water and then distributed in large sterilised Petri-dish containing two filter papers pre-moistened with 20 ml sterile distilled water. The dishes were transferred to a lightened, thermostatically controlled incubator at a constant temperature (25°C) and light intensity (6000 Lux) (Nosseir, 1968). At the 10<sup>th</sup> day of the commencement of the experiment 12 samples each composed of 50 beet seedlings were transferred to 12 sterilised

glass vessels, each fitted with sintered glass bubbler and containing 500 ml water or different culture solutions according to the following scheme.

- a) Normal Hoagland designated as  $N_{15}P_1$  solution.
- b) Normal Hoagland + 0.002 M  $NaNO_3$  designated as  $N_{17}P_1$  solution.
- c) Normal Hoagland + 0.005 M  $NaNO_3$  designated as  $N_{20}P_1$  solution.
- d) Normal Hoagland + 0.002 M  $NaH_2PO_4$  designated as  $N_{15}P_3$  solution.
- e) Normal Hoagland + 0.004 M  $NaH_2PO_4$  designated as  $N_{15}P_5$  solution.

Samples were distributed in their cultured media as follows:

Sample No	Treatment
1 : 2	500 ml of distilled water
3 : 4	500 ml of $N_{15}P_1$ solution
5 : 6	500 ml of $N_{17}P_1$ solution
7 : 8	500 ml of $N_{20}P_1$ solution
9 : 10	500 ml of $N_{15}P_3$ solution
11 : 12	500 ml of $N_{15}P_5$ solution

At the end of the experiment which lasted 7 days, the seedlings of each sample were taken out, washed with distilled water, dried gently with blotting paper then laid on squared paper for estimation of their linear growth. The samples were then air dried and weighed. After that, the samples were ground to a fine powder from which weights were taken and used to estimate their nutrient elements. Also the media were sampled at the end of the experiment and used for the analysis of their mineral composition. Phosphate ion was determined calorimetrically using molybdenum reagent together with  $\text{SnCl}_2$  solution (Nosseir, 1968). For nitrate determination a known weight of the powdered dry matter (100 mgm) is dissolved in 20 ml of 2% acetic acid solution. The mixture is then filtered and the filtrate is completed to 40 ml from which samples were determined calorimetrically using disulphophenolic acid (Peterburgski, 1954).

Potassium ion was determined by means of the flame photometer.

Ca and Mg were determined by titration against trilon according to the method adopted by Verugina (1956).

## Results

### Growth and development of beet seedlings acrated in culture media having different levels of NO<sub>3</sub> and PO<sub>4</sub> ions.

The total dry weight and the mean length of 50 beet seedlings cultured for 7 days in distilled water or Hoagland solution alone and in combination with different NO<sub>3</sub> and PO<sub>4</sub> levels are shown in Fig.(1). It is clear from this figure that beet seedlings cultured in Hoagland solution alone and in combination with different levels of NO<sub>3</sub> or PO<sub>4</sub>, ions have aquired much greater dry weights or linear growth rates over those of control seedlings and that the increase due to the presence of excess NO<sub>3</sub> ions was much higher than that due to the presence of excess PO<sub>4</sub> ions in the external culture media. In seedlings cultured in control solution (N<sub>15</sub>P<sub>1</sub>) the total dry weight recorded for 50 beet seedlings was 288.7 mgm as a mean value of 4 replicate samples while the mean length of these 50 beet seedlings was 5.8 cm. Increasing the concentration of nitrate ions in the culture media by 13% and 26% and keeping the concentrations of all other ions caused increased of 28.4% and 35.2% in the total dry weight of the seedlings respectively over that of control seedlings and this was accompanied by highly significant increases

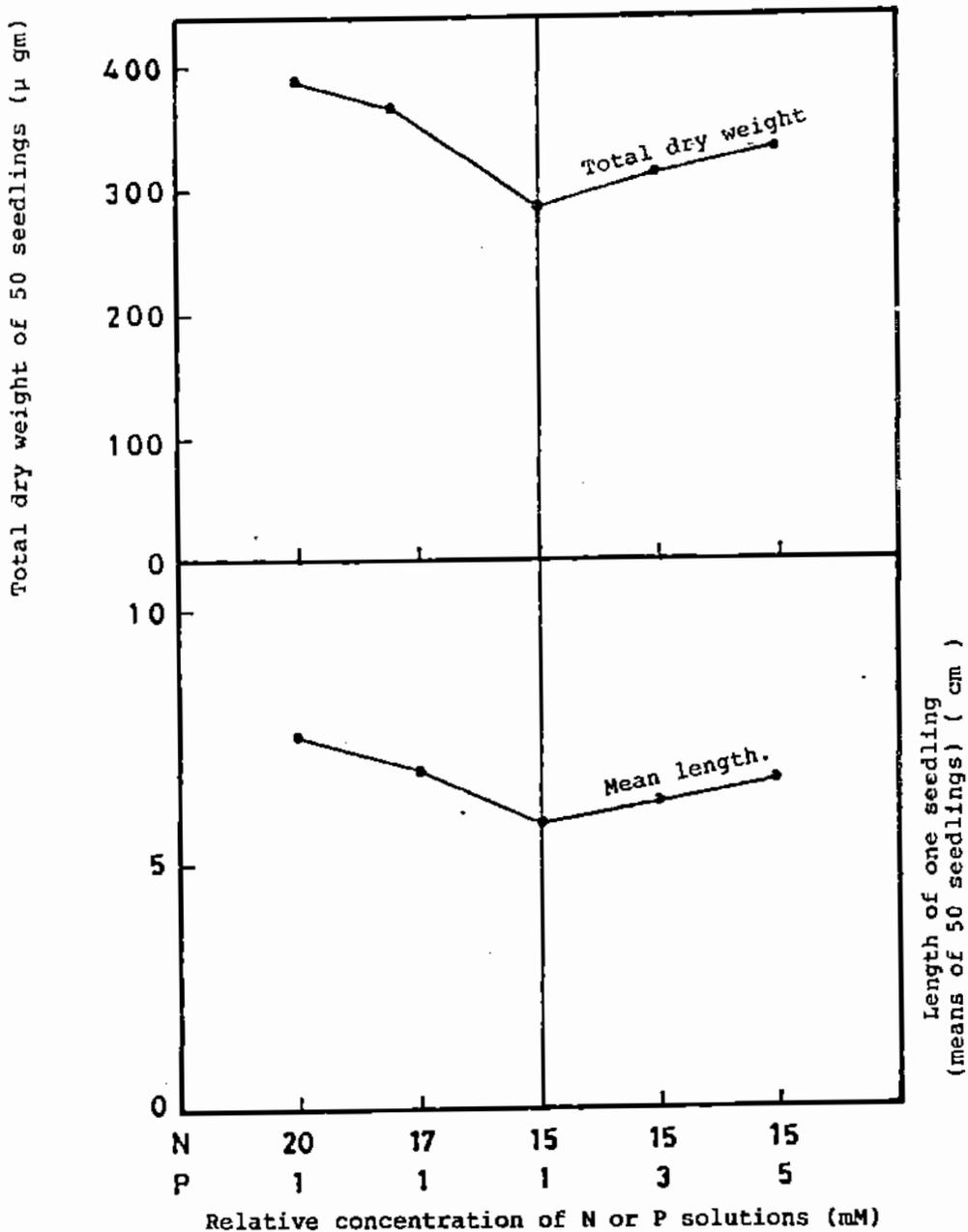


Fig.(1): Total dry weight (in mgms ) and mean length (in cm) of 50 beet seedlings cultured for 7 days in 500 ml distilled water or Hoagland solution alone and in combination with different  $\text{NO}_3$  &  $\text{PO}_4$  levels.

of 19.0% and 29.3% in the linear growth of the seedlings. Also increasing the concentration of phosphate ions in the culture media by 200% and 400% and keeping the concentration of all other ions remaining constant, caused increases of 7.5% and 17.9% in the total dry weight of the seedlings respectively over that of control samples and this was accompanied by significant increases of 6.9% and 13.8% in the linear growth of the seedlings.

Thus with both nitrate and phosphate increments in the culture media, the total growth rates of beet seedlings were increased. Such increases were enhanced by further increase in concentration of either of these ions in the nutritive media and that the increases due to increments of nitrate ions were more pronounced than those due to  $PO_4$  ion increments in spite of the presence of much higher concentrations of the latter ions over those of the former ions in the culture media.

Uptake and accumulation of nutrient elements and assimilation of nitrate as affected by different levels of  $NO_3$  and  $PO_4$  ions in the nutritive media.

Fig. (2) shows the relation between the relative concentration of  $NO_3$  or  $PO_4$  ions in the culture media and the element uptake per total dry weight of 50 beet

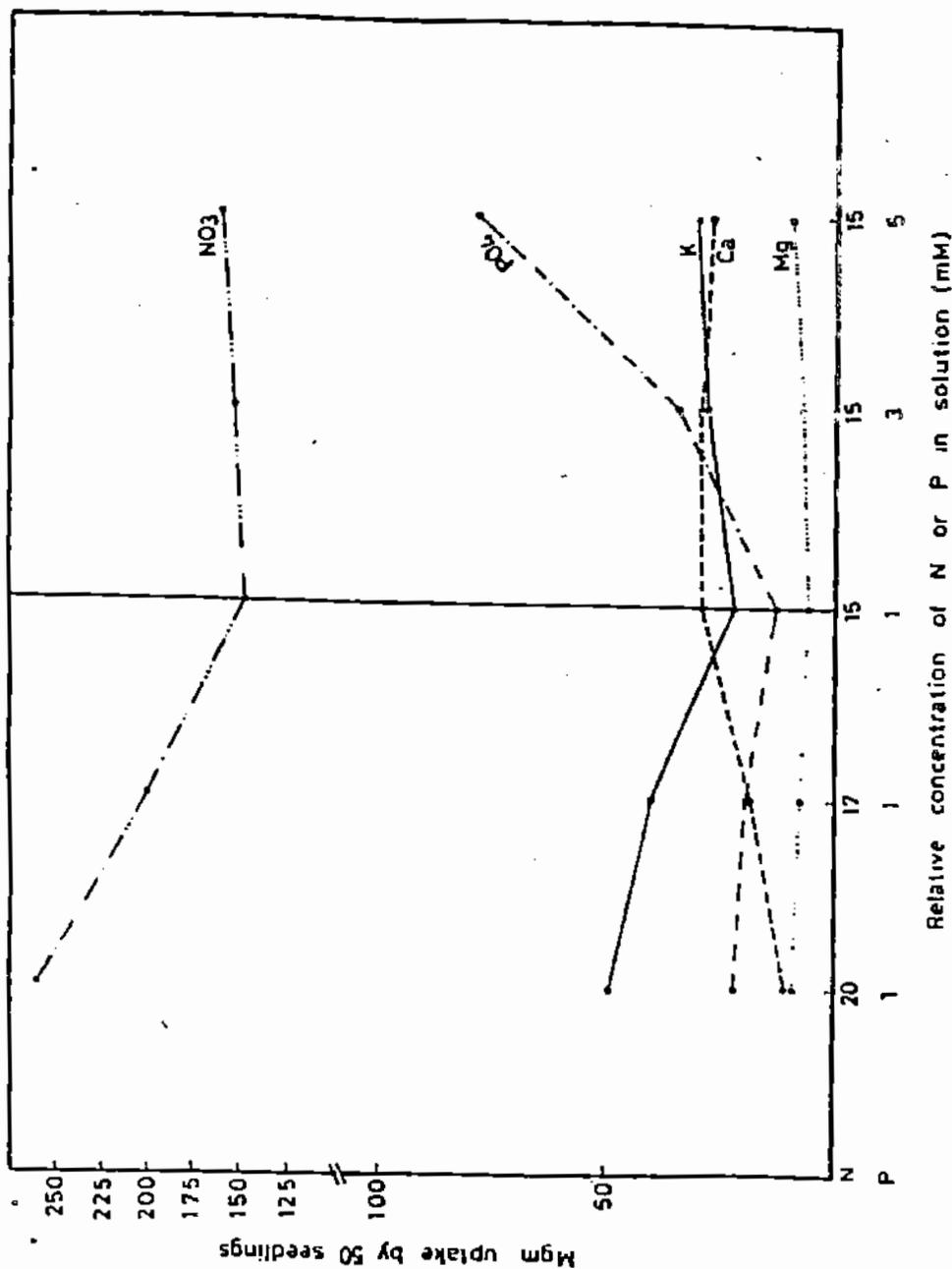


Fig. (2) Uptake of nutrient elements by 50 beet seedlings cultured for 7 days in 500 ml. of Hoagland solution alone and in combination with different nitrate and phosphate levels.

seedlings. It is clear that increasing the concentration of  $\text{NO}_3$  ions in the nutritive media by 13% and keeping the concentration of all other ions remaining constant, resulted in increases in uptake of K, Mg,  $\text{PO}_4$  and  $\text{NO}_3$  ions by 82.8% 34.4%, 39.9% and 34.7% respectively over those of control seedlings cultured in  $\text{N}_{15}\text{P}_1$  solution with a simultaneous reduction in Ca uptake by 37.4% below that of controls. By further increase in  $\text{NO}_3$  ion concentration in the culture media by 26%, further increase in uptakes of K, Mg,  $\text{PO}_4$  and  $\text{NO}_3$  ions reaching 126.7%, 54.1% 62.5% and 75.6% respectively over those of controls were obtained with simultaneous further reduction in Ca uptake by 63.6% below that of control seedlings. On the other hand, increasing the concentration of phosphate ions in the nutritive media by 200% resulted in increases in uptakes of K, Mg,  $\text{PO}_4$  and  $\text{NO}_3$  ions by 26.7%, 27.8%, 153.7% and 3.4% respectively over those of control in  $\text{N}_{15}\text{P}_1$  solution with a simultaneous reduction in Ca uptake by 3% below that of controls. By further increase in  $\text{PO}_4$  ion concentration in the culture media by 400% further increases in uptakes of K, Mg,  $\text{PO}_4$  and  $\text{NO}_3$  ions reaching amounts of 36.2%, 28.6%, 160.8% and 8.3% respectively over those of control in  $\text{N}_{15}\text{P}_1$  solution with a simultaneous further reduction in Ca uptake by 7.8% below that of controls were obtained. From the above results, it can be concluded that the

increases in uptake of nutrient elements and the simultaneous decrease in Ca uptake were proportional to the concentration of either nitrate or phosphate ions in the culture media and that the increases due to presence of  $\text{NO}_3$  ions were greater than those due to the presence of  $\text{PO}_4$  ions in spite of the much higher concentration of the latter over those of the former ions in the culture media.

As regards the interrelationship among nutrient ions as being occurred in beet seedlings consequent to their feeding with culture media having different concentrations of  $\text{NO}_3$  and  $\text{PO}_4$  ions and hence different N/P ratios, Fig.(3) was designated to show the mineral composition and changes in mgms per total dry weight of 50 seedlings as compared with controls cultured in  $\text{N}_{15}\text{P}_1$  solution. From Fig. (3), it is clear that increasing nitrate or phosphate ion concentration in the culture media, the accumulation resulting from absorption of all nutrient elements by beet seedlings were increased except Ca and nitrate ions which were decreased. Such changes were shown to be proportional to the concentration of  $\text{NO}_3$  and  $\text{PO}_4$  ions in the culture media. Fig. (4) represents the relation between N/P ratios in beet seedlings and the same ratio in the corresponding nutritive media. It is clear that N/P ratio found in control seedlings was 9.9 corresponding to ratio of

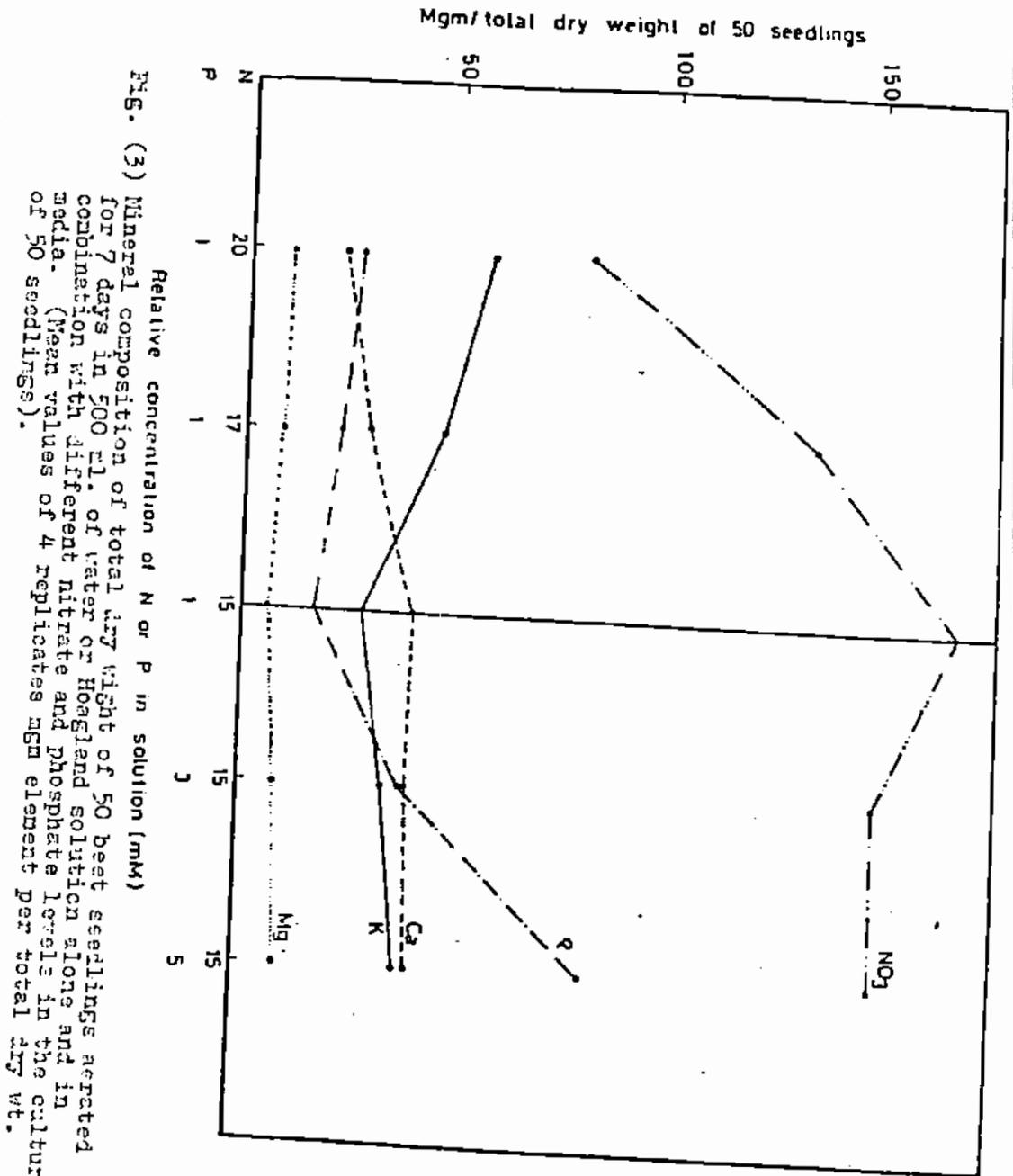


FIG. (3) Mineral composition of total dry weight of 50 best seedlings reared for 7 days in 500 ml. of water or Hoagland solution alone and in combination with different nitrate and phosphate levels in the culture media. (Mean values of 4 replicates mgm element per total dry wt. of 50 seedlings).

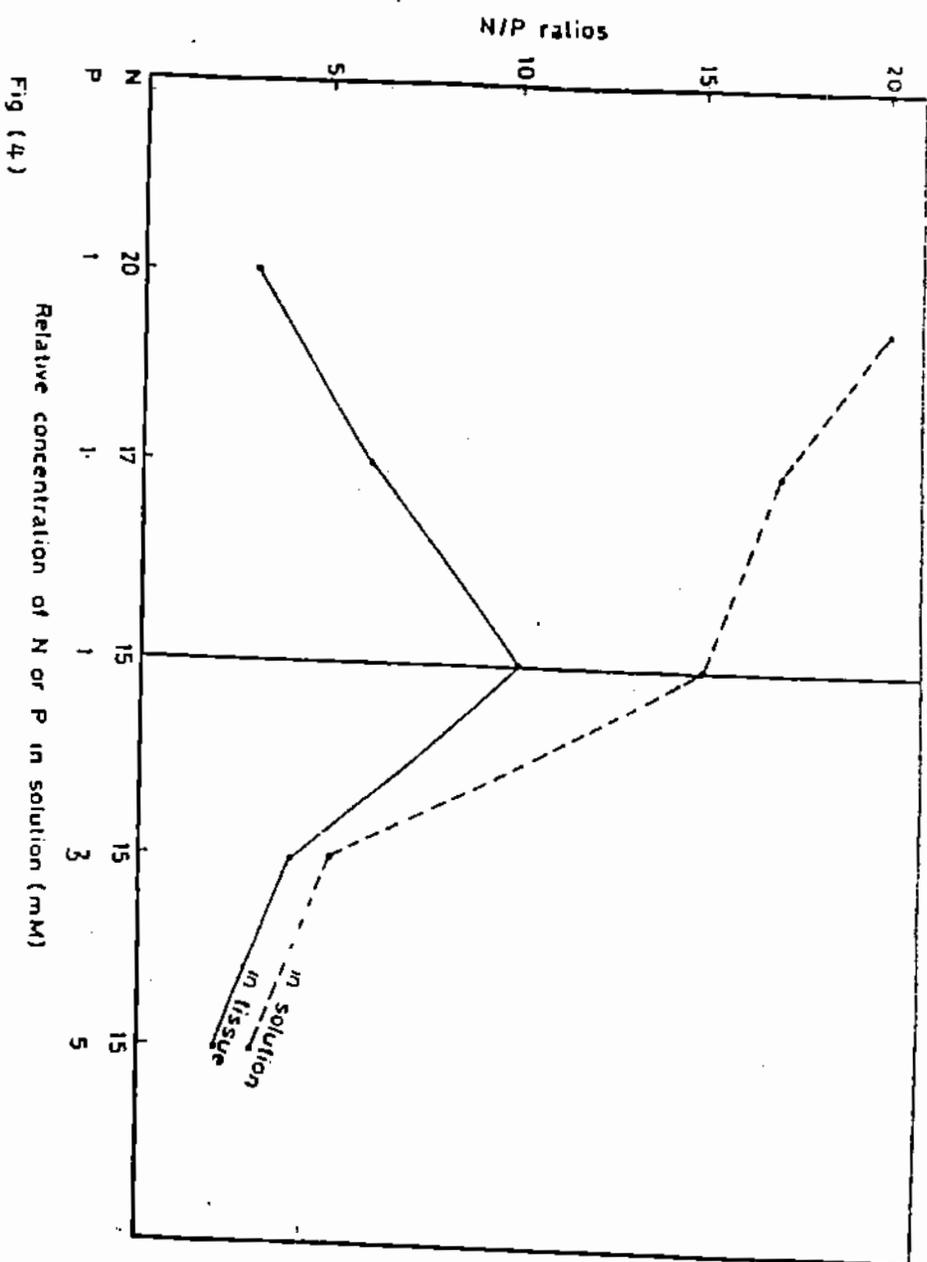


Fig (4)

Relation between N/P ratios in the culture media of 50 beet seedlings aerated for 7 days in Hoagland solution alone or in combination with different  $\text{NO}_3^-$  or  $\text{PO}_4^{3-}$  levels in the culture media and corresponding ratios found in the tissues. (Means of 4 replicate samples).

15/1 found in the respective media. Increasing the concentration of  $\text{NO}_3$  ion in the external solution and keeping the concentration of all other ions remaining constant led to high N/P ratio in the media but to low N/P ratios in the respective beet seedlings. On the other hand increasing the  $\text{PO}_4$  ion concentration in the culture media under similar conditions, led to low N/P ratio in the nutritive media accompanied by parallel ratios in the respective media indicating that the accumulation of  $\text{NO}_3$  or  $\text{PO}_4$  ions in beet seedlings was dependent on the concentration of these ions in their culture media. However, the divergent relationship between N/P ratios in beet seedlings and their respective culture media having progressive increases in  $\text{NO}_3$  ions might be due to the variations that took place in nitrate assimilation under such nutritional conditions. The nitrate assimilated by beet seedlings cultured in media having different N/P ratios is represented by Fig. (5) in mgms per total dry weight of 50 beet seedlings. It also shows the increases in the assimilated nitrate ions due to the presence of different concentrations of nitrate or phosphate ions in the culture media. It is clear that control beet seedlings assimilated 31.9 mgms nitrate per total dry weight of 50 seedlings. Increasing the concentration of nitrate ion in the culture media by 13% and 26% and keeping the concentration of all other ions remaining constant resulted in increases

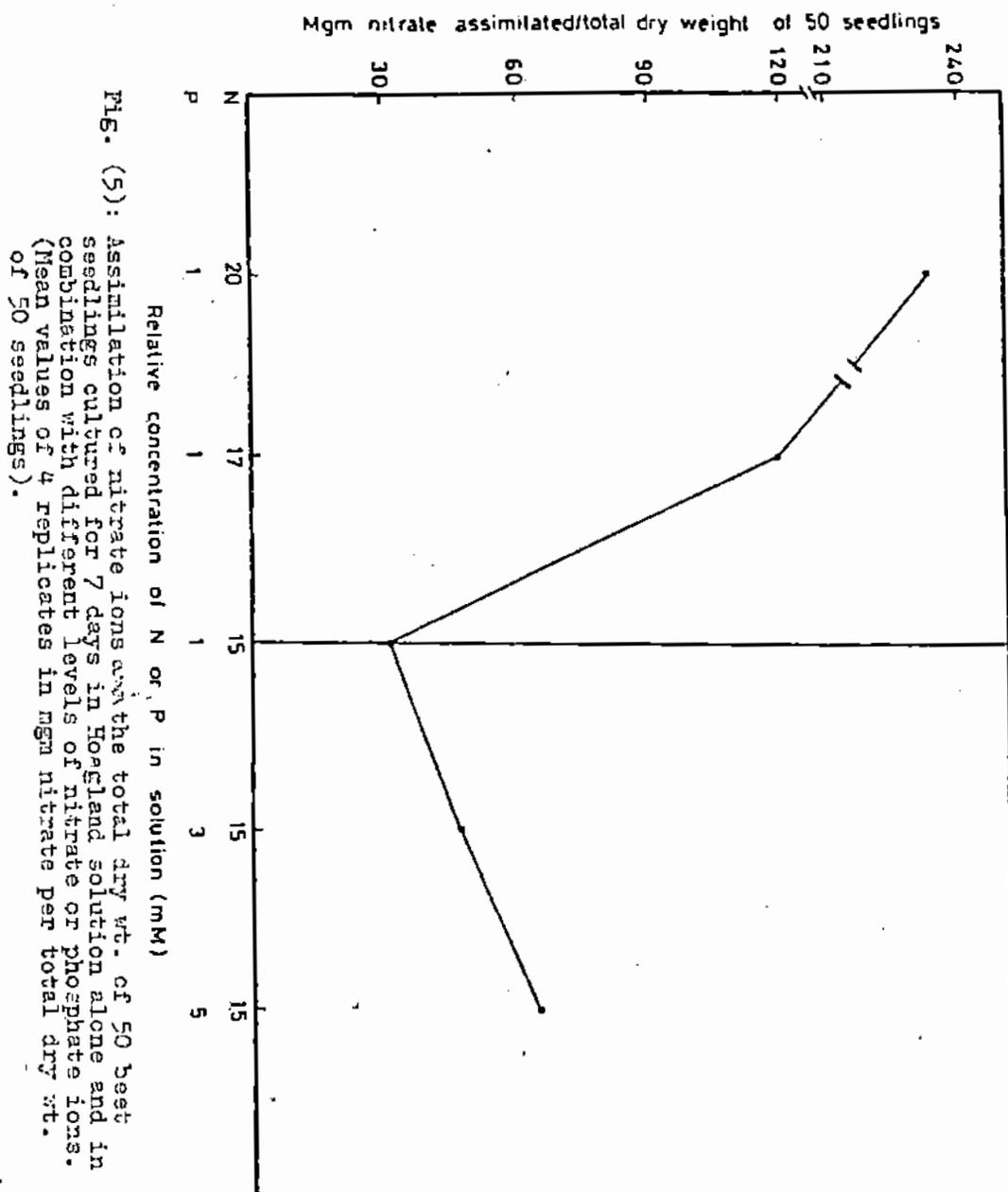


FIG. (5): Assimilation of nitrate ions and the total dry wt. of 50 best seedlings cultured for 7 days in Hoagland solution alone and in combination with different levels of nitrate or phosphate ions. (Mean values of 4 replicates in mgm nitrate per total dry wt. of 50 seedlings).

of 274% and 632% respectively in nitrate assimilation over that of control seedlings leading to low accumulation of nitrate ions in the tissues and hence the low N/P ratios in the tissues in spite of high N/P ratios in the culture media.

In such case, it seems that the rate of nitrate assimilation goes faster than the rate of its accumulation. Also increasing the concentration of  $PO_4$  ions by 200% and 400% , under similar conditions, causes 78% and 99% increases in nitrate assimilations over that of control seedlings. Here the rate of nitrate assimilation goes parallel to the amount absorbed.

#### Discussion

#### Growth and development of beet seedlings aerated in culture media having different levels of $PO_4$ and $NO_3$

The close relationship that existed between total growth and nitrate or phosphate as well as other nutrient elements can be seen by comparing the total growth of the seedlings cultured in different levels of  $NO_3$  or  $PO_4$  with those of control seedlings cultured in normal nutrient solution ( $N_{15}P_1$ ). For both nitrate and phosphate ions, the increases in total growth of the seedlings were stimulated by the increase of concentrations of

either of these ions in the nutritive media. Here growth was observed to be related to the uptake and accumulation of nutrient ions except Ca and nitrate. Ca is not shown, in the present work, to be related to growth, since increases in growth rates were accompanied by low accumulation of Ca in the tissues. Also nitrate accumulation was low in spite of its high uptake from the nutrient solution. The low accumulation of nitrate ion in the tissues is actually due to its assimilation and its incorporation in the synthesis of organic nitrogenous compounds. The above results were found concordant with the results of many workers.

Cole et al.(1963) found that N or P increments in the nutritive media caused significant increases in the growth of corn seedlings suggesting a connection between N and P metabolism and that increases in P levels in the tissues may reflect higher levels of N-intermediates. Nosseir and Hathout (1970) found that increases in the N concentration of the culture media stimulated the uptake and accumulation of P in sweet-potato tuber discs. However, Dumbroff and Michel (1967) found that increments of P in the nutrient solution of pine seedlings stimulated growth and development of these seedlings with simultaneous accumulation of N and other ions especially Mg and K. Also growth of

these seedlings was dependent on the increases of N & P levels in the nutritive media.

Uptake and accumulation of nutrient elements and nitrate assimilation as affected by different levels of  $\text{NO}_3$  and  $\text{PO}_4$  in the nutritive media.

It is clear from Fig. (2) that increasing the concentration of  $\text{NO}_3$  ions in the nutritive media by 13% and 33% over controls and keeping the concentration of other ions remaining constant, resulted in progressive increases in uptakes of K,  $\text{PO}_4$ , Mg and  $\text{NO}_3$  ions, and in progressive decreases in Ca uptake. The increases in uptake of nutrient ions and simultaneous decrease in Ca uptake were proportional to the concentration of the  $\text{NO}_3$  ions in the nutritive media. These results not only indicate that the absorption of nitrate was dependent on its concentration in the nutritive media, but also indicate the connection between N uptake and uptake of other ions.

On the other hand, increasing the concentration of  $\text{PO}_4$  ion in the nutritive media by 200% and 400% over controls resulted in progressive increases in K, Mg,  $\text{PO}_4$  and  $\text{NO}_3$  uptakes and in progressive decrease in Ca uptake. All these processes were found dependent on the concentration of  $\text{PO}_4$  ions in the nutritive media.

These results indicate the connection between  $PO_4$  uptake and the uptake of other ions sharing in the metabolism of beet seedlings. From Fig. (3) it is clear that the accumulation of all ions was increased over controls except Ca and nitrate ions which were decreased. But the changes due to the presence of excess  $NO_3$  ions were more pronounced than due to the presence of excess  $PO_4$  and that these changes were proportional to the concentration of  $PO_4$  or  $NO_3$  ions in the nutritive media. The decrease in nitrate accumulation in spite of the associated increase in its absorption is presumably due to its assimilation and disappearance from the tissue consequent to its incorporation in the synthesis of nitrogenous compounds. These results might receive emphasis from the work of Vichery et al. (1936) who found that the  $NO_3$ -N supply to beet plants resulted in the formation of organic nitrogenous compounds mainly proteins. Also Said & El Shishiny (1949) found that Nitrate-N plays the major role in the synthesis of protein in radish root tissues. Nosseir (1972) came to the same conclusion using pea seedlings. The positive correlation between uptake and accumulation of N and those of P by beet seedlings clearly show the connection between the uptake and metabolism of N and P. Such correlation was also shown by Nossier and Spiridinov (1965) using Phaseolus seedlings, Nosseir & Hathout

(1970) using sweet potato and Nosseir (1972) using pea seedlings.

From Fig. (4) it is clear that N/P ratio found in control seedlings is 9.9 corresponding to 15/1 found in the respective culture media. Increasing the concentration of  $\text{NO}_3\text{-N}$  in the external media and keeping the concentration of the other ions remaining constant led to high N/P ratio in the media but to low N/P ratios in the respective beet seedlings. On the other hand, increasing the  $\text{PO}_4$  ion concentration in the nutritive media under similar conditions led to low N/P ratios in the nutritive media accompanied by parallel ratios in the respective seedlings.

In this respect, beet seedlings behaved like pine seedlings since Dumbroff and Michel (1967) found parallel correlation between N/P ratios in the pine seedlings and their culture media.

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