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Response of Tomato Growth to Foliar and Soil - Applied Nitrogen Alone or With Potassium and Phosphorus
II.Nutrients Concentration

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ABSTRACT

The study was conducted on loamy sand soil under trickle irrigation system during the growing season of 1993-1994 to study the effect of different N rates (0, 60, 120 and 180 kg N/ha) and application methods (soil or foliar) of N alone or in combination with P (15 Kg P/ha) and/or K(60 kg K/ha) in addition to the effect of spraying plants with solutions containing P(15 kg P/ha),K (60 kg K/ha) or their combination on leaf N, P and K concentrations. Samples were collected 5 times during the period of fertilizer application (starting from Nov. through Feb.). Cores of soil sample were also taken at depth of 0-30 and 30-60 cm during the period from Nov. through Feb. in order to investigate the effect of rates and methods of urea application on inorganic N content (NO_3^{--} & NH_4^{+}) in soil. Increasing applied N rates by either of the application methods significantly increased N concentration in leaves, but it showed little effect on P or K concentration. Spraying plants with solution containing P, K, NP or PK did not result in significant effect on N concentration among each other. Spraying plants with solution containing P significantly increased P concentration in leaves. Spraying plants with solutions containing K significantly increased K concentration in leaves compared to other treatments. Inorganic soil nitrogen increased with increased rates of soil applied N, but was only slightly affected by foliar applied N. Soil NO_3^{-} N decreased and $NH4^{-}$ N increased as the growing season progressed.

INTRODUCTION

Applied N to soil may be lost from soil environment throguh losses through leaching which result in pollution of ground water, or by denitrification. These losses may reduce the effeciency of applied N to be between 30-60% (Termar and Noggle, 1988). Therefore, under adverse soil conditions which favour N losses and leaching from plant-soil environment foliar-applied N could be an alternative to soil applied N (Malakondaiah et al., 1981). However, data in literature show variable response of different crops to foliar-applied nutrients. Das and Patro (1984) and abdul (1978) reported substantial increase in yield and N, P and K concentrations of tomato plants, resulting from foliar N. On the other hand, data of Hamar and Ver (1972) and Gezerel (1986) indicated no effect from foliar spray of N on growth, yield or nutrient concentrations of tomato plants. Foliar sprays of nutrients to other crops have also given variable results (Sesay and Shibles, 1980, Harder et al., 1982; Garcia and Hanway, 1976).

This experiment was designed to study the response of tomato plants grown under soil conditions, which may increase potential for N losses from plant-soil environment to different rates of N alone or in combination with PK applied as foliar or through soil fertilization. The effect of experimental treatments on growth and yield of tomato plants was reported in a previous paper (Abdulkareem and Al-Ansari, 1996). The object-ives of this paper were to report the effect of experimental treatments on concentrations of N, P and K in leaves of tomato plants during growing season, in adition to the effect of fertilizer N rates and methods of application on NH_4^+ and No_3^-N content of soil during growing season.

MATERIALS AND METHODS

In growing season of 1993-1994, tomato plants were grown on a loamy sand soil with high levels of $CaCO_3$ and pH in Al-Burjsia Research Station, University of Basrah, Iraq. Soil prop-erties of experimental site, design and procedure of this study were described in details in a previous paper (Abdulkareem) and Al-Ansari, 1996). Tomato seeds var. Supermarmande were planted directly in soil in middle of Aug. 1993. The experimental plots were arranged in a splitplot in a renadomized complete block design with three replications. The experimental plots were under trickle irrigation system. Urea was applied at rates of 0, 60, 120 and 180 kg N/ha. Halves of these rates were applied to soil at planting time. The remaining halves of urea alone or in combination with P(15 kg P/ha), K (60 kg/ha) or Pk were applied to plants either as foliar application or soil application at weekly intervals starting at flowering stage and continued for nine weeks. Details of experimental treatments were described previously (Abdulkareem and Al-Ansari, 1996).

Leaf samples (upper fourth leaves) were collected biweekly starting one week after foliar spraing and continued through spraying period. Last sampling was collected one week from the last spraying. Leaves were dried at 70^{o}C. The dried leaves were ground using 20-mesh screen to prepare them for chemical analysis. Samples were analyzed in a laboratory at Basrah Univ., Coll. of Agric., Dept. of Soil Science. Samples of 200 mg of ground leaves were digested by sulfuricperchloric

acid as described by Cresser and Persons (1979). Total N was determined by a modified micro Kjeldahl. Phosphorus was determined colorimetrically, while potassium was determined using a flame photometer. Analysis of variance of nutrient concentrations is reported in Table 1.

Soil samples were taken at 30 and 60 cm depths from exp-erimental plots treated with different rates of N only as foliar or soil application during Nov., Dec., Jan., and Feb. Each sample was mixed, subsampled and extracted immediately with 1m KC1. Ammonium and NO_3-N in the extracts were determined by steam distillation technique (Bremner and Kenney, 1966). Analysis of variance of NH_4 and No_3 content is presented in Table 2.

RESULTS

Nitrogen :

Concentration of N in leaves increased consistently with amount of applied N at all sampling dates, regardless of application methods (Fig.1). Concentration of N in leaves sprayed with solutions contained N alone or in combination with PK did not change significantly throughout the first three samplings (from mid Oct. through end of Dec.), then decreased rapidly at fourth sampling (end of Jan.), after that it remained relatively constant till last sampling (end of Feb.) in N treated plants, whereas this reduction in N concentration continued till last sampling in leaves of check plants. However, N concent-ration of leaves of plants fertilized with N alone or NPK through soil fertilization increased throughout the first three samplings (at all N rates) then declined as the season progressed.

Methods of N or NPK application didn't significantly affect N concentration in the leaves throughout sampling period, except at first sampling, when in all treatments the N concentration of leaves sprayed with N solutions showed significantly higher N concentration than that of soil applied nitrogen.

Upper portion of Fig.2 clearly showed that spraying plants with solutions containing P (0.025 mole P/L) or K (0.087 mole K/L) only did not significantly affect N concentration in leaves when compared with those of plants sprayed with solution containing 60 kg N/ha (0.12 mole N/L) throughout the sampling period, but were significantly lower than those of plants receiving 120 (0.24 mole N/L) or 180 kg N/ha (0.36 mole N/L). Continuation of these differences in leaves N concentration depended on N concentration in spray solution. When plants were sprayed with solution containing 120 kg N/ha (0.24 mole N/L), the differences diminished at fourth sampling, while it continued till last sampling in plants sprayed with solution containing 180 kg N/ha (0.36 mole N/L). Lower por-tion of Fig.2 indicates that spraying plants with solution cont-aining P(0.025 mole P/L), K(0.087 mole K/L) or PK combined with different N rates didn't significantly affect N concentr-ation in leaves. However; data showed that N concentration in leaves of plants sprayed with solutions containing PK alone were significantly lower than those of plants sprayed with solutions containing N in addition to P or K. These differences depended on N concentration in spray solution. As the N con-centration in solution increased, the difference among plants sprayed with PK solution and those sprayed with other solutions increased.

Phosphorus :

Spraying plants with solutions containing different N rates alone did not significantly affect P concentration in leaves throughout sampling period,regardless of application methods. Phosphorus concentration in leaves at all N rates increased during the period between first and second sampling, then remained relatively constant till third sampling, after which it declined till last sampling (Fig.3). Data in Fig.3 also indicate that supplying plant with different rates of N combined with PK didn't significantly affect P concentration in leaves with both application methods (soil and foliar). Nevertheless, leaves of treated plants showed higher P concentration than those of control plants. Concentration of P in leaves of plants sprayed with solution containing PK combined with different N rates didn't change significantly throughout the first three samplings, then it decreased as the season progressed. However, P concent-ration in leaves of PK and different N rates treatments through soil fertilization increased during the first three samplings and then declined till last sampling.

Methods of application did not result in significant differ-ences in P concentration of leaves of plants treated with different rates of N alone or in combination with PK.

As regarding of spraying plants with solutions containing P(0.025 mole P/L), K(0.087 mole K/L) or different N rates on P concentration, data in Fig.4 (upper portion) clearly show that P concentration in leaves of plants sprayed with solution containing P was significantly higher than those of other treat-ments which were not significantly different from each other throughout sampling period.

There were no significant differences in P concentration among leaves of plant sprayed with solutions containing PK, NP or NPK at different N rates, but it were significantly higher than those of plants sprayed with solutions containing NK (lower portion of Fig.4). At all treatments P concentration remained relatively constant during the first three samplings followed by reduction as the season progressed.

Potassium :

With both application methods spraying plants with solu-tions containing different N concentration alone didn't signific-antly affect K concentration in leaves. However, when PK com-bined with N in spray solutions, K concentration in leaves increased consistently with increasing amount of applied N. Moreover K concentration in leaves of treated plants was higher than those of control plants.

In all treatments, concentration of K in leaves increased during the period between first and second or third sampling, then either slightly decreased or remained relatively constant during the rest of sampling period (Fig.5). Methods of application did not significantly affect K concentration in leaves at all sampling dates.

As of the effect of spraying plants with solutions containing P(0.025 mole P/L), K (0.087 mole K/L) or different N rates, data in upper portion of Fig.6 indicate that K concentration of leaves of plants sprayed with soltion containing K was slightly higher than those of other treatments, which were not different among each other throughout sampling period.

Spraying plants with solutions containing PK, NK or NPK at different N rates did not result in significant effect on K concentration in leaves, but were significantly higher than those of plants sprayed with solution containing NP only at all N rates (lower portion of Fig.6). In all treatments K concentration in the leaves increased during the period between first and second or third sampling, after that it either slightly decreased or remained relatively constant till last sampling.

Inorganic soil nitrogen :

Fig.7 presents N03 and NH_4 content in soil at two depths (0-30 and 30-60 cm) as affected by N rates, application methods and by time of sampling.

Data indicate that effect of N rates on $N0_3$ content of soil at both depths depended on application method. When N fertilizers were applied to soil, $N0_3^-$ and NH_4^+ content of soil at both depths were significantly increased with increasing N rates. The NO3 and NH_4 content at 0-30cm depth were significantly higher than those of 30-60 cm depth. However, when N fertilizers were applied plants through foliar fertilization, different N rates did not significantly effect $N0_3^-$ nor NH_4^+ content in soil at both depths. with both application methods, $N0_3$- and NH_4^+ contents of check plot were significantly lower than thoseof treated plots. Regardless of application method or rate of N, and at both depths, $N0_3^-$ content decreased significantly between first sampling (in Nov.) and third sampl-ing (in Jan.),then increased at last sampling (in Feb.). However, NH_4^+ content in treatments increased as the season progressed.

In general, soil application methods resulted in higher soil $N0_3^-$ and NH_4^+ content as compared to their respective treatm-ents of foliar

application method. Moreover, as the N rate incr-eased, the differences $N0_3^-$ and NH_4^+ conent due to method of application increased, and this effect was more pronounced in 0-30 cm depth than 30-60cm.

DISCUSSION

Results of this study indicated that N concentration in leaves of tomato plants increased consistently with amount of applied N, regardless of application method. These results are in agree-ment with those of Widder (1991), Das and Patro (1989) and Kastori (1987). However, spraying plants with P, K or PK did not result in a significant effect on N concentration in leaves.

Phosphorus concentration in leaves was not significantly affected by spraying plants with solutions containing N, K, Nk or NPK applied as foliar or through roots. Das and Patro (1989) reported that spraying tomato plants with solution containing 2% urea significantly increased N and K concentra-tions in leaves, but decreased P concentration. Results of Malakondaiah et al. (1981) showed that foliar fertilization of alfalfa and barley plants with N and P increased the concentr-ation of these nutrients in plants much more than their applica-tion to soil. Dumenil and Hanway (1965) reported that N appli-cation may increase, decrease or have no effect on P concentration in leaves of corn plants and the effect depends on N levels in leaves and rates of N application.

Potassium concentration in leaves of treated plants did not significantly differ, but were slightly higher than those of control plants. These results supported findings of Dumenil and Hanway (1965) on corn plant and Al-Zobai (1985) on tomato plants, who reported that different

N rates didnot significantly affect K concentration in leaves of corn or tomato plants. On the other hand, Yamada et al. (1965) reported that presence of urea in spray solution change some cuticl characterists which enhance uptake of k.

Data of this study showed higher concentrations of N, P and K in leaves of early sampling dates followed by reduction as the season progressed. High nutrient concentrations in leaves early in the season observed in this study are in agreement with those reported by other investigators for different crops (Al-Ansari, 1985; Thiab, 1996; Hanway and Weber. 1971). Terman and Noggle (1972) reported that high nutrient concentration in young plants apparantly occurred as a result of relatively more rapid rate of uptake than growth. This may occur with any nutrient that is present in sample supply in readily available forms, but without appreciable increase in growth. In later stage, rate of plant growth is relatively much greater, and dilution of most nutrient concentration and-or translocation is the dominant trend.

The effect of N rates on inorganic N ($N03^-$ and NH_4^+-N) in soil depended on application methods, when N applied to plants through soil, $NH4^+$ and $N03^-$ content significantly increased with N rates. However, with foliar applied- N different N rates did not show significant effect on $N0_3$- or NH_4^+-N content in soil at both depths. It is interesting to note that, in spite of light soil texture (loamy sand), and with borth application methods movement of $N03^-$ or NH_4^+ to lower soil depth was limited, Since soil inorganic N ($N03^-$ and NH_4^+) in upper depth (0-30 cm) was significantly higher than in lower depth (30-60cm) at all sampling times.

These results could be due to presence of a crop which could significantly reduce rate of inorganic N leaching to lower soil depths (Black, 1968). Showing a differ-ent trend from what is usually noticed in incubation studies of N -transformation in soil, field data of this study showed that $N03^{-}N$ content decreased and NH_4^{+} content in soil increased with time in all sampled treatments.

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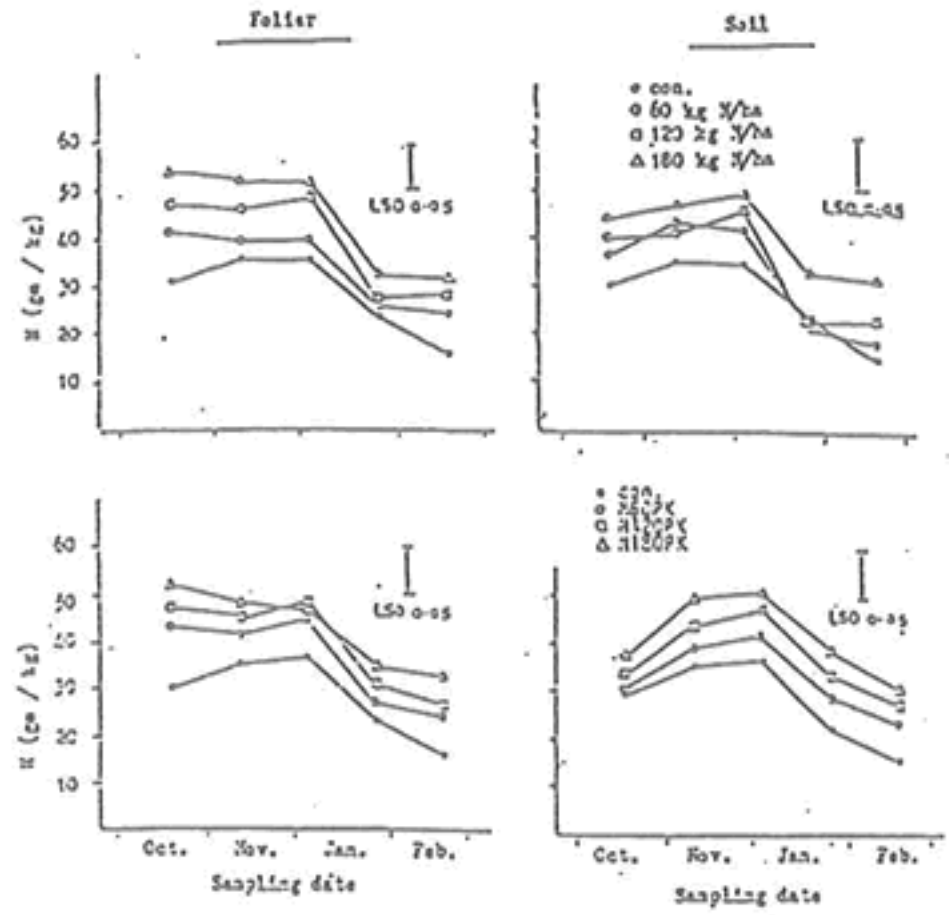

Fig. 1 : Effect of application methods of N or NPK on nitrogen concentration in tomato leaves through the growing season.

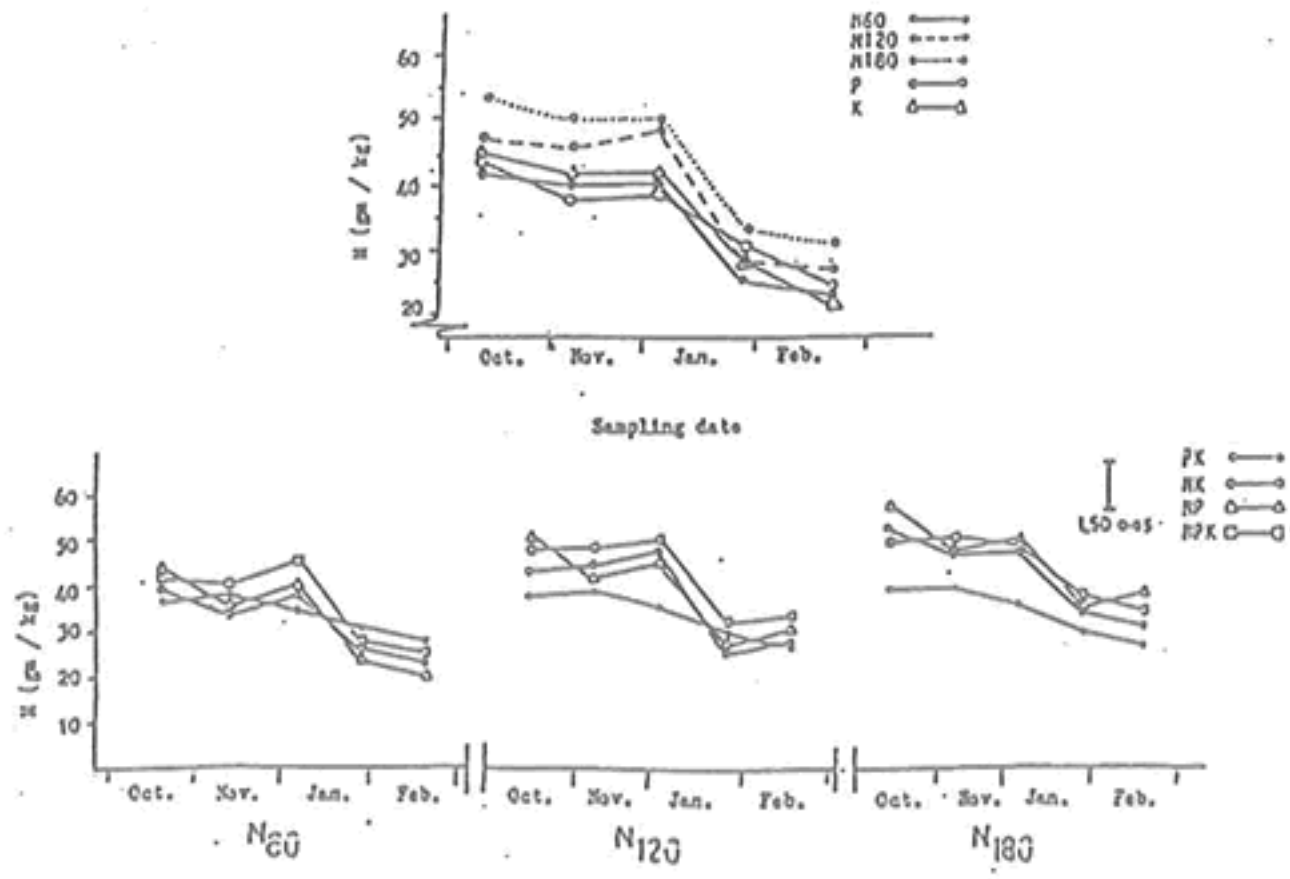

Fig. 2 : Effect of N , P or K spraying (upper portion) or their interactions (lower portion) on nitrogen concentration in tomato leaves through the growing season .

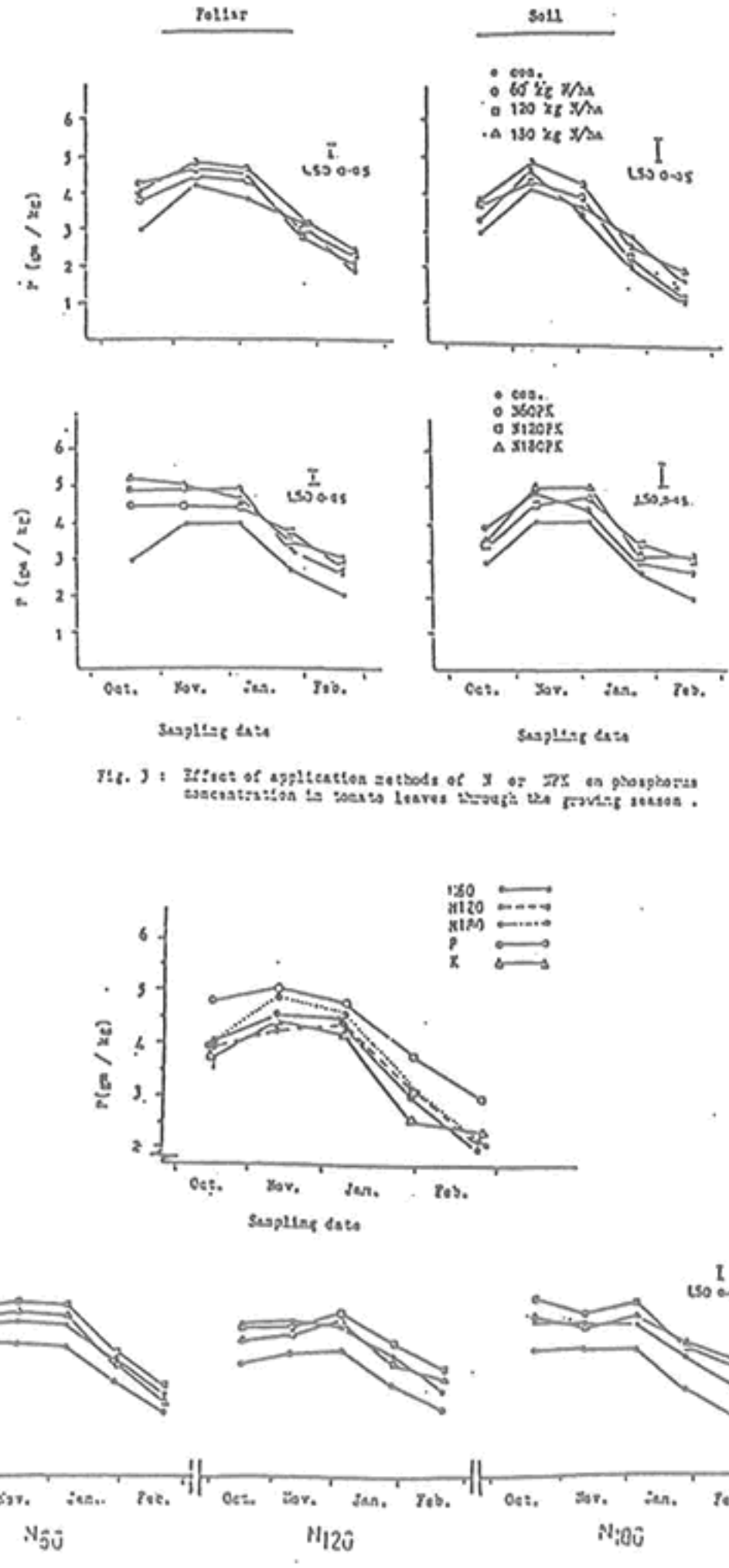

Fig. 3 : Effect of application methods of N or NPK on phosphorus concentration in tomato leaves through the growing season .

Fig. 4 : Effect of N , P or K spraying (upper portion) or their interactions (lower portion) on phosphorus concentration in tomato leaves through the growing season .

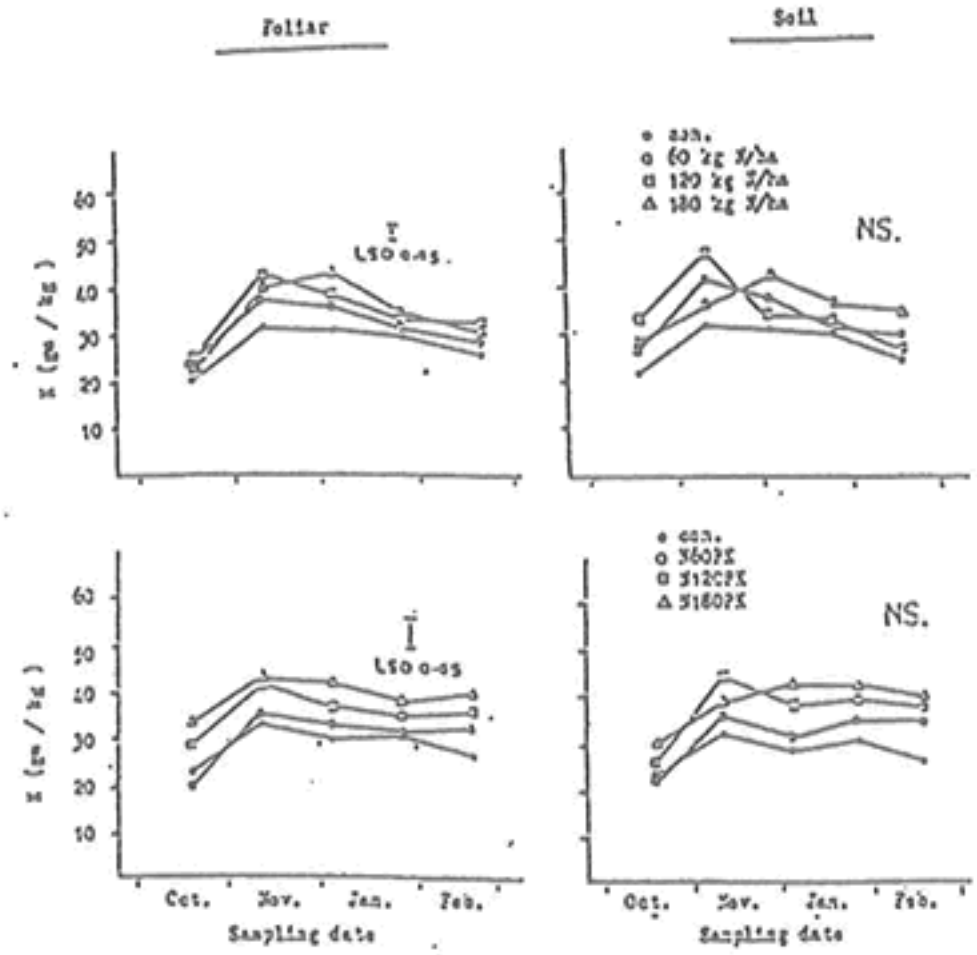

Fig. 5 : Effect of application methods of N or NPK on potassium concentration in tomato leaves through the growing season .

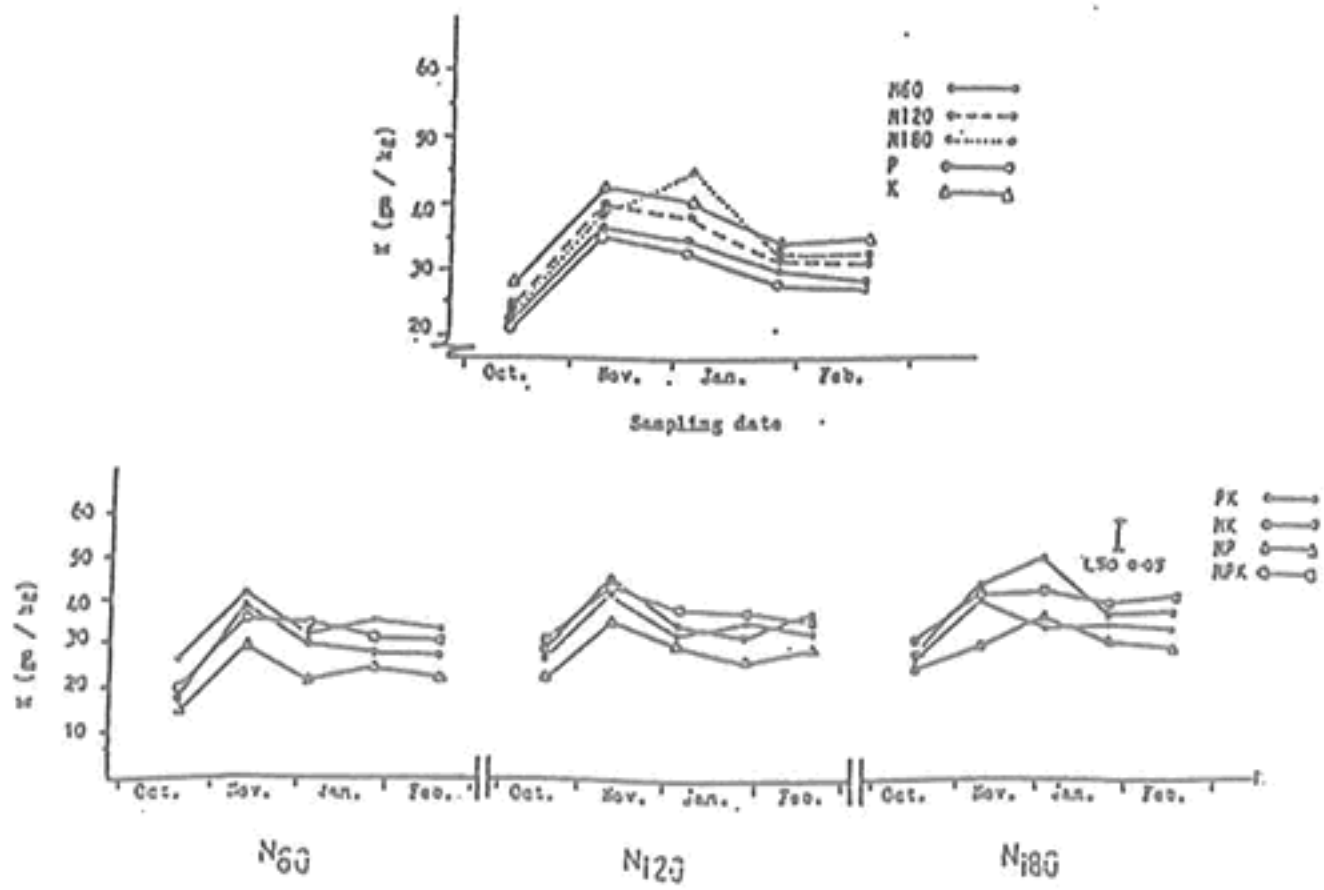

Fig. 6 : Effect of N , P or K spraying (upper portion) or their interactions (lower portion) on potassium concentration in tomato leaves through the growing season .

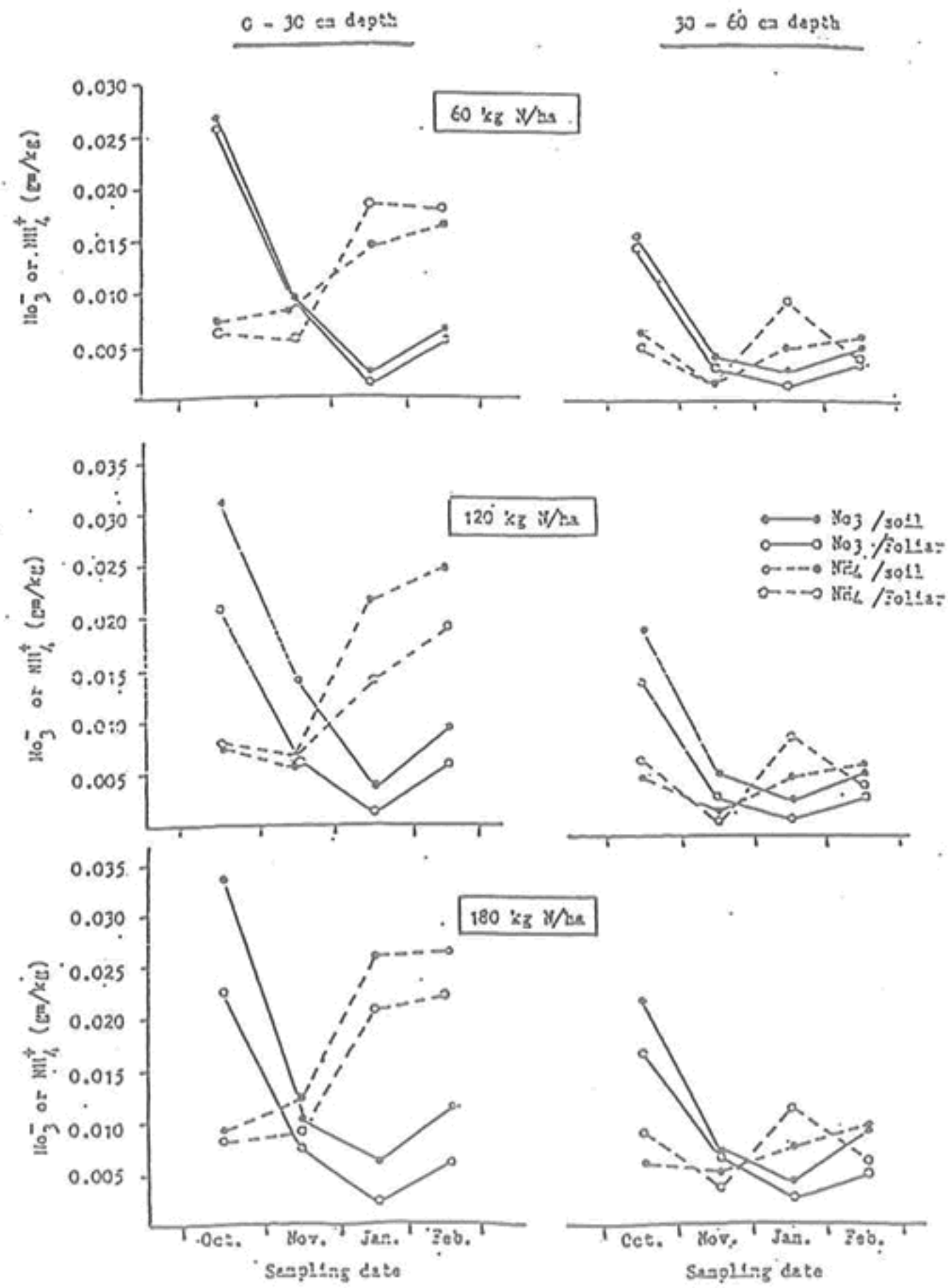

Fig. 7 : Effect of application methods and N rates on No_3^- and NH_4^+-N content at two depths of soil through the growing season .

تأثير إضافة النتروجين ، منفردا أو متداخلا مع الفسفور والبوتاسيوم بالرش أو الى التربة على نمونبات الطماطم .
٢- تركيز العناصر

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ملخص :

تم أخذ عينات ورقية من نباتات الطماطم المزروعة في تجربة حقلية في تربة رملية مزيجية والمروية بنظام الري بالتنقيط خلال موسم النمو ٩٣-١٩٩٤. استخدمت العينات الورقية لدراسة تأثير مستويات مختلفة من النتروجين (صفر ، ٦٠ ، ١٢٠، ١٨٠ كغم N/هكتار) وطرق اضافة مختلفة (الى التربة أو رشا على الجزء الخضري للنبات) سواءاً أضيف النتروجين منفردا أم متداخلا مع الفسفور (١٥كغم P/هكتار) أو البوتاسيوم (٦٠ كغم K /هكتار) أو كلاهما ، وتأثير رش النبات بمحلول يحتوي على الفسفور فقط (١٥ كغم P/ هكتار) أو البوتاسيوم فقط (٦٠ كغم K /هكتار)، أو كلاهما على تركيز النتروجين والفسفور والبوتاسيوم في الأوراق . أخذت العينات خمس مرات خلال فترة اضافة السماد (تشرين الثاني - شباط). كذلك تم جمع عينات تربة ولعمقين (صفر - ٣٠ و ٣٠-٦٠سم) خلال الفترة من تشرين الثاني الى شباط لبيان تأثير مستويات وطرق اضافة اليوريا على محتوى التربة من النتروجين المعدني (النترات والأمونيوم). ان زيادة النتروجين المضاف بأي من الطريقتين رفع معنويا من تركيز النتروجين في الأوراق فيما كان تأثيره بسيطا على تركيز الفسفور والبوتاسيوم . أما النباتات التي رشت بمحلول يحتوى على الفوسفور أو البوتاسيوم أو NP أو PK فأنها لم تختلف معنويا فيما بينها بمحتواها من النتروجين . ان رش النبات بمحلول يحتوي على الفسفور قد زاد معنويا من تركيز الفسفور في الأوراق ورش النبات بمحلول يحتوي على البوتاسيوم زاد معنويا من محتوى البوتاسيوم في الاوراق ، مقارنة بمعاملات الرش الأخرى . أوضحت النتائج ان هناك زيادة في محتوى التربة من النتروجين المعدني بزيادة مستويات النتروجين المضافة بطريقة النثر على السطح ، ولكن التأثير كان بسيطا بالنسبة لطريقة الرش . لقد انخفض محتوى التربة من النترات وازداد من الامونيوم بتقدم موسم النمو.