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Effects of Foliar Fertilization and Growth Regulators on Growth and Yield of Tomato Plants

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EFFECTS OF FOLIAR FERTILIZATION AND GROWTH REGULATORS ON GROWTH AND YIELD OF TOMATO PLANTS

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G. A. R.

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INTRODUCTION AND OBJECTIVES

Foliar fertilization or the direct application of plant nutrients to the foliage has been successful in increasing the yeilds of crops. This method of fertilization is particularly important in situations where 1). nutrients applied to the soil are fixed or unavailable, 2). nutrient deficiencies appear during the growing season and rapid correction is desired. In addition, the drip of run-off is not lost for it falls on the soil from which it may later be absorbed.

Absorption of nutrient elements through the leaf, stem and bark takes place rather easily, however, large amounts of nutrient ions cannot be applied at any one time because of the possibility of leaf damage. Thus, it is difficult to supply the total macronutrient needs of plants by this means. A possible exception is the application of nitrogen as urea.

Micronutrients and some of the secondary nutrients can be satisfactorily applied as foliar sprays since only small amounts are needed.

Foliar fertilization is used most frequently on fruit trees and vines. However, it has also been used on row crops. small grains and vegetables. This is a unique method for the nutrient elements can be applied simultaneously with insecticides, fungicides, pesticides and growth stimulants.

This study was designed to determine the effects of foliar fertilization in combination with growth regulators on the height and dry matter yield of tomato plants.

LITERATURE REVIEW

A. Tomato Response to Fertilizers

Davidescu and Davidescu (1960b) sprayed tomatoes three times late in the season with a solution of 5% nitrogen (NH_4NO_3), 1% phosphorus (super phosphate), 1.0% potassium (K_2SO_4) and 0.01% boron. They recorded an increase of yield up to 17%/ Mel'nichuk (1960) cited by Barel (1975) obtained yield increases from 30 to 39% after using foliar sprays composed of NP, NK, and PK solutions. NPK solutions increased yields up to 48%. On the other hand, Mostert and Sonneveld (1964) showed that when tomato plants were adequately supplied with NPK in the soil there was not a yield increase to foliar application of NPK. Bottoni and Morra de Lavriano (1958) reported that tomato growth was more than doubled by sprays of 0.06% of $(NH_4)_2PO_4$ applied twice weekly.

B. Rate of Uptake, Nutrient Composition and Translocation of Elements Within the Plant

Hanway and Weber (1971b) measured the amount of N, P, and K in the various parts of the plant at 10 stages of development. They found a linear rate of nutrient uptake between full bloom and "green bean" stage. Their data show also increasing rates of uptake prior to full bloom. However, after the "green bean" stage, the nutrient uptake rate decreased to 0. These authors (Hanway and Weber, 1971a,d) showed average accumulation rates of 4.5, 0.4, and 1.5 kg/ha/day of N, P, and K for the whole plant during the period of full bloom to seed-filling. During the same period, total dry weight increased 167 kg/ha daily. The rate of nutrient accumulation was slow in early stages followed by a rapid increase at the beginning of flowering. After flowering, and until senescence, nutrient uptake continued at a relatively constant rate.

Harper (1971) reported the NO_3 showed a peak in uptake during pod set and early seed-filling. He also observed that P and K showed a peak between full bloom and midpod fill. deMooy et al., (1973) stated the rate of nutrient accumulation relative to that of dry matter has a bearing on nutrient needs at various stages of development of the plant. When the nutrient and dry matter data from Hanway and Weber (1971b) is superimposed, it shows little difference in accumulation rate through the season, except during bloom when the absorption of N and P lagged behind dry matter accumulation. These authors showed that 40% of the N, 45% of the P and 40% of the K are absorbed after the beginning of bean formation.

deMooy et al., (1973) stated that nutrient absorption is rapid in relation to dry matter production during early stages. As a consequence of this, the nutrient concentrations are high at these stages. Later, due to the rate of accumulation of dry matter and to the translocation of nutrients to developing seeds, the nutrient concentration of the various tissues generally decreases.

Hanway and Weber (1971b) reported increasing P and K contents in the leaves, petioles and stems until the three-leaved stage. After this stage, these authors showed that the nutrient concentration steadily declined in all parts.

Data from several authors (Hanway and Thompson, 1967; Hanway and Weber, 1971a, b, c, d; Harper, 1971; Henderson and Kamprath, 1970; Hammond et al., 1951) showed that N, P, K, Ca, and Mg concentrations in the total plant tended to decrease throughout the season until the last weeks. During the last few weeks, the contents changed very little if fallen leaves were accounted.

The data of Hanway and Weber (1971c) confirmed the facts that cultivars differed little in composition; N content at stage R7 was between 5 to 6% in leaves, 4% in pods, 2.5 to 3.5% in stems, and 2 to 3% in petioles. At stage R 7.0 the N content was 6.5% in seeds, 2% in leaves, 0.9% in pods, 0.7% in petioles and 0.6% in stems. Henderson and Kamprath (1970) reported a downward trend in the vegetative parts from 3.6% N at 40 days to 1.0% at 140 days after planting. On the other hand, the N content of the seeds and pods increased from 3.8% in the beginning to 4.8% at maturity.

The data shown in the preceding paragraphs support the concept that late in the growing season there is an active translocation of nutrients from the vegetative tissues into the forming seeds. This phenomenon leads to the depletion of nutrient from the leaves, which in turn cannot carry on photosynthesis and therefore senescence occurs.

Photosynthate is also translocated to the regions of energy utilization, or sinks, which include the roots (Thrower, 1962, 1965), apex, floral buds, seed and leaves (Winter and Martimer, 1967). It seems that before flowering, the photosynthate is translocated from mature leaves to roots, new leaves, and the apical meristem (Aronoff, 1955; Belikov, 1955a, b, 1958; Belikov and Pirskii, 1966). The recipient of the photosynthate is determined by the distance between the source and potential recipient (Belikov, 1955a, 1957b; Belikov and Pirskii, 1966; Crafts, 1967).

Two distinct patterns of translocation of labelled assimilates appear to exist in soybeans (Thaine et al., 1959; Bloomquist and Kust, 1971). Before pod filling, translocation from a given leaf occurs to meristematic areas above the leaf. As the leaf ages and its position changes relative to the stem apex, more and more of its exports are directed downward. Most of the assimilates going into the roots come from lower leaves on the plant. After pod filling starts, translocation from a given leaf occurs primarily to the pods in the axil of that leaf and at the second node below that leaf (Bloomquist and Kust, 1971). Only very small amounts of label have been recovered from the roots and nodules after pod filling (Hume and Criswell, 1972).

Several authors (Aronoff, 1955; Belikov, 1957a, Crafts, 1967; Hicks and Pendleton, 1969; Koller, 1971) have proposed that photosynthate sinks exert a demand for phytosynthate and that the magnitude of the demand decreases with distance from the source. Belikov (1957a,b) concluded that the demand by seeds for photosynthate must be greater than the amount normally supplied.

Products of phytosynthates also provide energy for the nodules. It has been shown by Lawn and Brun (1974) that symbiotic nitrogen fixation in soybeans declined during pod filling as the result of inadequate assimilate supply to the nodules.

Thibodeau and Jaworski (1975) suggested that there is a close and competitive relationship between the process of nitrate reduction and nitrogen fixation, with the latter process dominating as the major source of fixed nitrogen after the plants have flowered and initiated pods. The rapid decay of nitrogen fixation at the time of midpod fill suggests a competition between roots (nodules) and pods for available photosynthate. This competition appears to lead to the breakdown of foliar protiens and senescence (Thibodeau and Jaworski, 1975).

C. Feasibility of Foliar Fertilization

During the past twenty years several reviews have been written on foliar absorption. Tukey et al., (1956, 1971), Biddulph (1960), Wittwer (1964), and Wittwer et al., (1965) agreed that foliar fertilization with N and P is feasible under different conditions and on a variety of crops. Quite a bit of research on the subject has been done in Europe. It has been summarized by Burghardt (1961), Ferenz (1963), and Biftnik et al., (1957).

Kick and Hellwig (1959), cited by Barel (1975), reported that sunflowers could be completely supplied with nitrogen, phosphorus and potassium through foliar applications. Burr et al., (1956) determined that the total amount of P required by sugar cane would be supplied by foliar sprays of KH_2PO_4. Wittwer (1956) found that 1 to 5 sprays of 0.03% orthophosphoric acid applied during the early fruit growth supplied 70 to 80% of the total phosphorus mobilized into tomato fruits. He further observed that the application of nutrients to the leaves of plants would likely have its greatest merit as a means of supplementing in the supply of nutrients ordinarily supplied to the roots.

Thirty years ago a great interest developed to study foliar absorption of mineral nutrients using radioactive reaces. As a result, the determination of accurate pathways of uptake and translocation as well as a means of distinguishing between nutrients absorbed simulteneously b the leaves and by the roots.

D. Pathways of Absorption and Translocation of Foliar Sprays

Although the absorption of nutrients by leaves is a multiple process, Franke (1967) concluded that the whole process took place in three stages. In the first stage, the solution applied on the leaves penetrates the cuticle and cellulose wall by way of free diffusion. Once the solution has penetrated the free space, the second stage takes place with the adsorption of the solution to the surface of the plasma membrane by some form of binding. In the third step the adsorbed substances are taken up into the cytoplasm in a process requiring metabolically derived energy.

This process does have obstacles as was concluded by Franke (1967). The cuticle was thought to be the major obstacle, with absorption taking place mainly through stomatal pores. However, this has only the effect that solutions enter cavities such as stomatal pores. However, this has only the effect that solutions enter cavities such as stomatal chambers and intercellular spaces, and not the cells themselves. The outer walls of cells lining these cavities are still covered by an internal cuticle. So the problem still persists, being shifted from the outer to the inner surfaces of the leaves. Soynton (1954) reported that uptake occurs probably through both cuticle and stomata.

Wittwer et al., (1965) demonstrated that diffusion through cuticular membranes is relatively rapid with urea being the most rapidly absorbed nutrient. This rate, according to Yamada et al., (1964b), increases with time. It is important to point out that some absorption takes place near the base of the leaf hairs, which have thinner cell walls or less cuticularization in that area (Linskins et al, 1965).

The second barrier encountered is the cell wall. It is penetrated by a multitude of small strands called ectodesmata. Many of these strands penetrate the outer walls of the epidermis and terminate beneath the cuticle. Franke (1967) suggested that the location and frequency of these ectodesmata are related to the phenomenon of foliar absorption. He also showed that turgid leaves contain more ectodesmata than wilted ones, and the number is much greater during the daytime.

The plasma membrane constitutes a third barrier. It is called semipermeable because it is permeable only for water. The penetration of compounds other than water has been the subject of many theories which are not fully developed.

E. Sources of Nutrients Used in Foliar Fertilization

Urea is the most widely used N source in foliar fertilization. It is used alone or in combination with many formulated mixtures. Barel (1975) tried different compounds containing phosphorus-nitrogen bonds and phosphorus-nitrogen-phosphorus linkages. Nearly all of the phosphorus compounds investigated by Barel (1975) were applied in ammonium form.

Relative to potassium and other nutrients, the soluble salt of each appears to be equally effective as foliar spray. Cook and Mitchell (1958) found that chelated zinc preparations were no better than inorganic sources for grapes. Lingle and Holmberg (1956) found that $ZnSO_4$ was more effective than the chelated form for vegetables. Haertl (1955) suggested that the type of foilage influenced the reaction of leaves to chelates. Firm and thick leaves often respond favorably; on the other hand, plants with soft and succulent foilage respond negatively.

F. Factors Affecting the Foliar Absorption of Nutrients

Several factors affect the absorption of nutrients by the leaves. They include the stage of development of the plant, the age of the leaf, leaf thickness, leaf surface and differences between cultivars and plant species. Environmental factors include air humidity, temperature, pH of the solution applied and addition of sugars and surfactants (Tukey at al., 1956).

G. Response of Different Crops to Foliar Fertilization

The literature on this subject is scarce and sometimes contradictory. An attempt to summarize some of the work done on different crops is in the following section.

Yield increases were recorded by Chumakov and Bystiova (1958). Combined sprays of urea and superphosphate on wheat produced an increase in yields of 14% as reported by Narayanan and Vasudevan (1957) in Russia.

Very little research on foliar fertilization of corn has been conducted; and usually only one or two nutrients have been tested. Narayanan and Vasudevan (1959) reported an 18% increase of weight of maize cobs after spraying the plants with superphosphate solution. Barel (1975) sprayed several condensed phosphates in a field experiment and obtained an increase in yield statistically significant when compared with the check.

DeDatta and Mormane (1965) found that sugar cane plants grown on strongly phosphorus fixing soils responded significantly to four foliar sprays of phosphorus as mono-ammonium phosphate, as potassium phosphate or as superphosphate. Burr et al., (1958) found that the lower leaf surface of sugar cane absorbs more efficiently than the upper. Cresp (1964) reported that yields were increased by areial application of 15 pounds of phosphate per acre to plant cane.

Sugar beets seem to respond well to foliar fertilization. Thorne (1955b) showed an increase in yield and sugar as a result of spraying with an NPK solution. Milica (1959) sprayed sugar beets with an NPK solution three to four weeks before harvest and recorded an increase in root yield and sugar production of 26 and 35% respectively.

There are reports of yield increase due to complete foliar fertilization of coffee, cacoa (Ananth 1961; Carne 1966; Sato et al., 1954).

Bukovac and Wittwer (1957) found good absorption of phosphorus applied to bean leaves. Krzysh (1958) found that foliar spray of 0.35% phosphorus and soil application of phosphorus gave similar bean yields.

Foliar application of fertilizer macronutrients of field grain crops has not been advocated or practiced extensively. Numerous attempts have been made to raise yields of soybeans above average through soil fertilization. Results from limited studies by Barel (1975), Chesin and Shafer (1953), Schumacher and Welch (1970), Wittwer et al., (1963) of N and/or P foliar application on soybeans generally have not been encouraging.

Hanway and Garcia (1976) reported that results obtained from two years of field experimentation demonstrated conclusively that soybean yields can be significantly increased by foliar application of a NPK solution during the seed-filling period. Yield increase resulted primarily from an increase in number of harvestable seeds rather than seed size. This indicates that many seeds are normally initiated that are never filled and later aborted.

1. Wheat and small grains

Combined sprays of urea and superphosphate on wheat produced an increase in yield of 14% as reported by Naryanan and Vasudevan (1957) in Russia. Davidescu and Davidescu (1960a) sprayed with a 1% solution of NH_4NO_3 and superphosphate between tillering and ear formation and then followed with a 3% solution of NPK. After 5 sprays they reported an increase in yield of grain and straw and greater numbers of fertile ears and seeds per ear.

As a result of combined spray of P and K on wheat in the spring, the yield was increased by 38% as reported by Chumakov and Bystrova (1958). Ferencz (1954) cited Barel (1975) showed a small increase in wheat yield after several sprays of a 5% superphosphate solution. Rozhanovskii (1956) cited by

Barel (1975) reported an increase in yield of wheat up to 1.53 ton/ha after spraying wheat growing on podzolic soils.

Asbour and Saleh (1973) applied urea on wheat. A treatment that consisted of a 1% solution increased the number of spikes per plant and produced the highest yield. Foliar application of urea also produced taller plants and more tillers. Working with different times of foliar application of urea on wheat, Jain and Agarwal (1973) determined that two sprays at 30 to 35 days after planting gave higher yields than did sprays applied at earlier growth stages.

Urea applied as foliar spray has been shown to interact with water stress. Alexander (1973) showed that with foliar application of urea and K, the grain production of wheat was less affected by water stress under rain-fed conditions. Comparing urea with NH_4NO_3, Vertil and Malyuga (1970) determined that the two forms were equally effective in increasing accumulation of glutin, protein, tryptophane, and phosphorus, and in improving the fractional composition of the protein. They tried urea solutions up to 40% without showing any sign of damage. Mathus et al. (1969) showed a 2% solution of urea spray containing 11.2 kg/ha of N increased grain and straw yields. This increase was not greater than the increase from the same amount of nitrogen applied to the soil. The same kind of results were reported by Nerson and Karchi (1972). De (1971) reported increases in wheat yield, up to 60%, due to spraying a solution of 10 to 20% urea at a rate of 36 l/ha.

Foliar sprays with microelements have also reen reported to increase wheat yield, protein percentages of the grain and shoot weight (Asbour and Hegazi, 1972).

Working with oats, Von Boguslawski and Vomel (1957) obtained increases in oat yield as a result of spraying with an NPK solution. Several authors showed significant yield increases of barley due to foliar spray using urea in concentrations up to 20% as a source of N (Bezdek and Flasarova, 1973; Vonka and Bezdek, 1974; and Singh and Bains, 1973). Spraying with a solution with 20% urea at a rate 39 l/ha, Chanham et al. (1971) showed an increase in yield of rice up to 15% (34.5 kg grain/kg applied N). Equivalent figures for experiments with wheat were 23.5% at a rate 73 l/ha and 31%. Bhaskaran and De (1971) applied 100 kg/ha of N to rice; 20% was applied as foliar spray (3% urea solution) or as top-dressing. The highest yield was a result of the foliar spray treatment.

2. Soybeans, sunflowers and cotton

Barel (1975) tried different condensed phosphates applied as foliar sprays on soybeans in a field experiment. He reported an increase in yield (significant at the 18% level) of 256 kg/ha when the check plot was compared with the treatment that received 28 kg/ha of P as ammonium tripolyphosphate. In another experiment, Barel (1975) determined the maximum concentration of P as condensed phosphates that could be applied to soybean plants in the greenhouse. Also the response of plants to spraying with these P compounds was investigated. The yields of plants sprayed with the different P compounds significantly exceeded the yeilds of the unsprayed control with all P sources except tripolyphosphate. Sprays with tripolyphosphate produced considerable leaf damage, which was reflected in the weight of 100 seeds. Barel (1975) determined that soybean plants growing in the greenhouse can be grown to maturity when all the P they need was supplied by sprays.

Shukla (1974) reported that a foliar application of 15 or 30 kg/ha of P to soybenas produced a higher yield than the same quantities applied in the soil. On an acid clay soil, only foliar application of P increased the yield significantly. The protein content of the grain was increased due to the foliar P fertilization.

Belikov and Thatschenko (1961) cited by Barel (1975) and Belikov and Burtseva (1966, 1967) cited by Barel (1975) applied a 2% superphosphate solution on the leaves at the rate of 2 kg P/ha at the end of flowering. They reported that soybeans absorbed the P^{32} from superphosphate that was sprayed. They also found an increase in yield of 15 to 20% and an increase in total oil production of 16%.

Working with sunflowers, Galgoczi (1967) cited by Barel (1975) reported an increase in yield of 62 and 97% when the crop was sprayed one or two times with an NPK solution. Bhoj et al. (1969) sprayed cotton twice with a 0,2% solution of KH_2PO_4 in the greenhouse and obtained a significant increase in yield. Verma and Sahni (1963) reported similar results. Ferraz et al. (1969) showed that a urea solution up to 15% could be applied at a rate of 45 l/ha on cotton without damaging the leaves.

Kuthy (1954) sprayed lettuce seedlings with a 3 to 4% NPK solution and obtained a yield increase within 10 days. The production and protein yields of peas were increased with PK sprays applied at flowering. Khodzhaeva (1961a, 1961b) cited by Barel (1975) obtained the highest yield increases (up to 20%) after spraying strawberries with a NPK solution. He reported that four-year old plants responded more than two-year-old plants and that fall spraying increased the number of berries and spring spraying increased the berry size.

In apples Ursulenko (1958) obtained an increase in production of 32% due to an increase of photosynthesis during the first 10 to 15 days after foliar sprays with P and K. McNall and Hinckley (1973) sprayed almonds with zinc, manganese and phosphorus. They reported an increase of 19% in yield over a 4-year period. Aliev (1967) sprayed grapes with a NPK solution and showed an increase in yield and sugar content of the berries. He also reported an acceleration of the ripening. Natali and Zucconi (1968) showed an increase of fruit yield of grapes by 22% after spraying 5 to 9 times with urea, phosphoric acid and potassium sulfate. This was in combination with NPK applied to the soil. Pecznik and Merei (1962) cited by Barel (1975) also working with grapes reported increases of yields up to 33% after spraying with a 2% superphosphate solution.

There are reports of yield increase due to complete foliar fertilization in coffee, cacoa, peach, pear and orange (Ananth, 1961; Carne, 1966; Madero Bernal, 1953; Sato et al., 1954; Eggert et al., 1952).

MATERIALS AND METHODS

This is a cooperative project between Allied Chemical Company and the College of Agriculture at Prairie View A&M University. The materials, methods, design, and procedure listed below are standards utilized by Allied in similar studies in other parts of the United States. Three crops (corn, tall fescue, and tomatoes) were involved in this cooperative project, however, only tomatoes are reported on in this current study.

Experimental Design

This greenhouse experiment was initiated on December 21, 1978 and it consisted of a randomized block design with each of the following thirteen treatments replicated four times:

1. Triacontanol 0.01 mg/liter
2. Triacontanol 0.10 mg/liter
3. Triacontanol 0.1 mg/liter
4. Benzilamino purine 20mg/liter
5. Triacontanol + Benzilamino purine 20mg/liter
6. Control

1. Folian and Triacontanol 0.01 mg/liter
2. Folian and Triacontanol 0.10 mg/liter
3. Folian and Triacontanol 0.1 mg/liter
4. Folian and Benzilamino purine 20mg/liter
5. Folian and Benzilamino purine and Triacontanol 20mg/liter
6. Folian and Triacontanol 20mg/liter

7. Control

NOTE: These are brand names developed by Allied Chemical Company, Houston, Texas.

Foliar Fertilizer

The analysis of the foliar fertilizer (Folian) was as follows: 12-4-4-.55-.1Fe.

Growth Regulators

The growth regulators were Triacontanol and Benzilamino purine (brand names developed by Allied Chemical Company).

Soil

The soil used in the experiment was Metro-mix Growing Medium 300, a scientific blend for professional use in horticulture and agriculture, prepared by W. R. Grace Company, Cambridge, Massachusetts.

Planting

Plastic pots (16 cm in diameter and 16 cm deep) were filled with soil and enough water was added to ensure good germination. Tomato seeds (Mariglobe variety) were planted at the rate of four seeds per pot in a square pattern, and then finally thinned to one plant per pot.

Spraying

The solutions were sprayed on the plants by use of a portable hand sprayer. The leaves were sprayed from above in such a way as to cause adherence of a maximum amount of solution with the least possible loss by dripping. The plants were sprayed once during the duration of this study.

Heights

The height of the tomato plants was measured twice during latter part of the experiment and three times during first part of the experiment with a ten day interval between the measuring dates.

Dry Matter Yield

After the last height measurements were made the plants were harvested by cutting at ground level. Individual plants were allowed to dry in the oven for 24 hours at 60° c, and the resulting weights were used as dry matter yields.

RESULTS AND DISCUSSION

The effects of growth regulators on height and dry matter yield of tomatoes

The average height and dry matter yield of the tomato plants for six treatments on three sampling dates are shown in Table 1. There were no significant differences in height between the six treatments and increasing the concentration of Triacontanol had no significant effect on growth during the early stage of growth (Tables I - III- V Appendix). However, Triacontanol appears to be more effective than Benzilamino purine in increasing growth (Table I). During the late stage of growth the growth regulators appear to decrease growth as compared to the control where the rate of growth was constant from one date to the next. Compared to the control, the growth regulators appear to increase growth during the early stage of growth and they tend to decrease growth during the late stage of growth. This general trend cannot be explained at this time and deserves further investigation.

There were no significant differences in dry matter yields between the six treatments (Table VIII -Appendix). These values ranged from a high of 25.3 grams for the control to a low of 14.7 grams for treatment number 4 (Benzilamino purine, 20mg/liter). The data in Table I appears to suggest that the over-all effect of the growth regulators is to reduce dry matter yield. While there were no significant differences, this situation deserves further study.

TABLE I. The Effects of Growth Regulators on Height and Dry Matter Yield of Tomato Plants.

Treatment*	Average Height (in.) Feb. 22	Mrs. 4	Mar. 13	Average Dry Wt. (g.)
1	18	27	31	21.2
2	16	25	30	19.3
3	15	24	27	20.4
4	18	25	29	14.7
5	17	24	30	18.9
6	17	23	29	25.3

*Treatment:

1. Triacontanol 0.01mg/liter
2. Triacontanol 0.10mg/liter
3. Triacontanol 0.1mg/liter
4. Benzilamino purine 20mg/liter
5. Triacontanol + Benzilamino purine 20mg/liter
6. Control

NOTE: These are brand names developed by Allied Chemical Company, Houston, TExas.

TABLE II. Average Height of Tomato Plant for Each of Seven Treatments on Two Sampling Dates.

Treatment*	Average Height (inches) March, 20	April, 1
1	17	23
2	16	25
3	16	23
4	15	23
5	15	22
6	14	19
7	15	23

*Treatments:

1. Folian and Triacontanol 0.01mg/liter
2. Folian and Triacontanol 0.10mg/liter
3. Folian and Triacontanol 0.1mg/liter
4. Folian and Benzilamino purine 20mg/liter
5. Folian and Benzilamino purine and Triacontanol 20mg/liter
6. Folian and Triacontanol 20mg/liter
7. Control

NOTE: These are brand names developed by Allied Chemical Company, Houston, Texas.

Effects of foliar fertilizers and growth regulators on height of tomato plants

The effects of foliar fertilizer (Folian - 12-4-4-.55-.1Fe) in combination with growth regulators (Triacontanol and Benzil-amino purine) on the height of tomato plants are shown in Table II. There were no significant differences in height between the seven treatments, (Tables VI and VII).

The author can not explain why there were no significant differences in height between the different treatments, however, several possible explanations are given below.

The first possibility is that the plants received sufficient nutrients from the soil. In this situation, foliar fertilization would have little or no effects. This possibility appears to be reasonable, since no nutrient deficiencies were observed. Another possibility is the time of application. The plants were sprayed sixty days after emergence, which is relatively old. The growth rate of younger plants would probably be affected more by the treatments than that of older plants. The other possibility is the growing condition in the greenhouse. On several occasions the temperature in the greenhouse dropped below freezing.

SUMMARY AND CONCLUSION

In this greenhouse experiment growth and dry matter yield were not significantly affected by the foliar fertilizers and growth regulators used in this study.

The above cannot be fully explained, however, it could be due to any one or combination of the following:

1). concentration and combinations of fertilizers and growth regulators.

2). time of application.

3). growing conditions in the greenhouse.

In view of the results obtained from this experiment, the author recommends that additional studies be conducted involving the following:

1). Different combinations of fertilizers and growth regulators; and

2). Spraying at different times during the growing cycle.

Because doses of fertilizers and growth regulators should vary with specific growing conditions, it is further recommended that reasonably optimum growing conditions be maintained in the greenhouse.

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APPENDIX

TABLE III. Analysis of Variance for Height, February 22, 1979

Source	DF	SS	MS	
Treatment	5	9.1	1.8	F Value
Error	15	52.7	3.5	0.51428
TOTAL	20	61.8		

Not significant at the 1% and 5% levels

TABLE IV. Analysis of Variance for Height, March 4, 1979

Source	DF	SS	MS	F Value
Treatment	5	7.5	1.5	
Error	15	52.5	3.5	0.42857
TOTAL	20	60.0		

Not significant at the 1% and 5% levels

TABLE V. Analysis of Variance for Height, March 13, 1979

Source	DF	SS	MS	F Value
Treatment	5	31	6	
Error	15	77	5	1.20000
TOTAL	20	108		

Not significant at the 1% and 5% levels

TABLE VI. Analysis of Variance for Height, March 20, 1979

Source	DF	SS	MS	
Treatment	6	23.8	3.9	F Value 1.77272
Error	18	40.4	2.2	
TOTAL	24	64.2		

Not significant at the 1% and 5% levels

TABLE VII. Analysis of Variance for Height, April 1, 1979

Source	DF	SS	MS	
Treatment	6	94.2	15.7	F Value 3.20408
Error	18	89.5	4.9	
TOTAL	24	183.7		

Not significant at the 1% and 5% levels

TABLE VIII. Analysis of Variance for Dry Matter

Source	DF	SS	MS	
Treatment	5	237	47	F Value
Error	15	513	34	1,38235
TOTAL	20	750		

Not significant at the 1% and 5% levels