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A STUDY OF THE INFLUENCE OF MOLYBDENUM AND ZINC ON THE GROWTH OF TOBACCO**

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INTRODUCTION

This study proposes to determine the optimum concentration of molybdenum and zinc, as was done (Yie, 1964) for the iron, manganese and boron, and (Yie, 1965) for copper and chlorine, for the growth of tobacco. The data from this experiment joined to the data of the two previous experiments will furnish as complete a knowledge as possible of seven micronutrients to be applied profitably to increase tobacco production.

The molybdenum is an essential element in plant metabolism was demonstrated by Lipman and Stout in 1939. After that Hoagland (1940) reported that Myrobalans showed molybdenum deficiency symptoms the leaves were dwarfed, some had a diffuse mottling, and many developed light brown areas of dead tissue at tips and margins. It has been shown by controls that a very low concentration 0.01 ppm molybdenum requirement was demonstrated in leguminous plant supplied with fixed nitrogen (Meagher, 1951) and that no symptoms appeared in any of the control plant receiving 0.01 ppm molybdenum. Molybdenum is also necessary for green algae, for example, molybdenum-deficient cultures in Chlorella are characterized by their low chlorophyll content, low dry weight, low photosynthetic rate and high rate of endogenous respiration (Loneragan and Arnon, 1954). Molybdenum was found to be essential for growth of Scenedesmus nitrogen assimilation and chlorophyll formation only in the nitrate culture (Arnon, 1955) but the requirement for molybdenum was abolished when nitrate was replaced by either urea or ammonium carbonate (Ichioka, 1955)

A number of disease conditions, especially of fruit trees, have been recognized to result from zinc deficiency. For example, apple shoot showing buds fail to develop, leaves are small and narrow (little leaf) and tend to form rosettes at tips of shoots. Reed (1942) reported that zinc deficiency cause the symptoms dwarfing of vegetative growth and failure of seed formation. It is well known that zinc is also necessary in the synthesis of indoleacetic acid, an important growth hormone in plants. All of these findings show it is very useful to demonstrate the appropriate amount of zinc for growth of tobacco.

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METHOD

Earlier methods of investigation revealed that molybdenum and zinc were needed in nutrient solution only in very low concentration. For this reason work with molybdenum requires careful purification of salts used in mineral nutritional solution, the using of insoluble glass container, and removal of contaminating minerals from distilled water. These special procedures were not necessary when studying deficiency symptoms of iron, manganese, or boron etc.

The material was the same kind of tobacco plant (variety Hicks) as was used previously (Yie, 1964). Tobacco seeds were germinated until the seedling had grown up to a height around three centimeters.

Hoagland's solution was used to supply macronutrient elemets.

In this study the micronutrient element concentrations used were as follows: boron 0.30 ppm, manganese 0.30 ppm, copper 0.06 ppm, chlorine 2.50 ppm, and iron 2.50 ppm, all of them were the optimum concentration for growth of tobacco (Yie, 1964, 1965).

The series of zinc concentration were prepared from 1 mg Zn/ml stock solution. To each of five crocks (2 gallons) zinc was added as follows: No zinc was added to the first pair of crocks, 0.19 ml of the stock 1 mg Zn/ml solution to each of the second pair of crocks and similarly 1.15 ml to the third pair, 9.5 ml to the fourth pair and 19.0 ml to the last pair of crocks.

The molybdenum series were prepared in the same way as the zinc series but the molybdenum requirement compared with zinc is much lower. Using 1 mg Mo/ml stock solution, molybdenum was added to the five crocks as follows: Add no molybdenum to the first pair crocks, 0.076 ml of the stock 1 mg Mo/ml solution to each of the second pair of crocks and similarly 0.46 ml to the third pair, 3.80 ml to the fourth pair and 7.60 ml to the last pair of crocks.

The aerator was connected to the compressed air line. The air values are to be adjusted so that a small stream of air bubbles through the culture solution. Each crock was filled up with the distilled water every day. At weekly intervals the appearance of the plants, both tops and roots as to size, color, leaf distortion, etc. was observed.

The pH value of the nutrient solution was measured once a week.

After several weeks, depending on the plant growth and weather, the plant were harvested, the fresh weight of tops and roots was determined. The tops and roots were then dried in an oven at 60°—70°C. The weights of the dried samples were recorded.

RESULTS

This experiment was carried out in the green-house of the Department of Botany, Taiwan Provincial Chung Hsing University from October, 1964, to June, 1965. During those months the water culture of each micronutrient series was repeated more than three times. A record of one series was selected to illustrate the influence of each micronutrient on the growth of plants.

A. Zinc series:

Tobacco was transplanted in various concentration of zinc for around five weeks from April 2, 1965, to May 8 of the same year.

The records showed that the concentration of zinc 0.151 ppm was the best for shoot growth (Table 1) and for the fresh weight and dry weight of both roots and shoots harvested (Table 2,3). If the concentration of zinc reached to 1.250 ppm the shoot growth decreased and fresh. dry weight was reduced (Fig 1; Tables 1, 2, 3). This data demonstrated the concentration of zinc 0.151 ppm to be suitable for tobacco growth. In the case of zinc deficiency were observed not only shorter height of shoot but also lower fresh and dry weight. The roots of zinc-deficient tobacco plant had fewer branches and were brownish in color. This was in contrast with white color and the usual fibrous type of root growth in 0.151 ppm zinc concentration (Fig 1). Comparison the same stage of young leaves growth at various zinc concentration showed great differences in size and appearance. The zinc-deficient leaf was notably smaller and folded but the leaf grown in concentration of zinc 0.151 ppm was much flatter and bigger than the others (Fig 2).

Table 1. *Shoot growth of tobacco at various zinc concentrations.*

Date \ Conc.	No zinc	0.025 ppm	0.151 ppm	1.250 ppm	2.505 ppm
	cm	cm	cm	cm	cm
2/4	1.6	1.55	1.65	1.6	1.6
9/4	3.05	3.1	4.55	3.7	3.05
16/4	5.5	7.5	18.5	8.7	6.8
23/4	7.05	11.0	25.5	13.5	9.5
1/5	11.51	23.0	40.0	23.5	19.0
8/5	13.0	29.0	55.0	36.5	25.0

Table 2. *The fresh weight of tobacco at various zinc concentrations.*

Conc. \ Part	Fresh weight of shoot	Fresh weight of root	Total fresh weight of shoot and root
	gm	gm	gm
No Zn	42.6	5.7	48.3
0.025 ppm	105.1	7.3	112.85
0.151 ppm	209.0	17.8	226.8
1.250 ppm	179.6	9.6	154.2
2.505 ppm	125.6	7.9	133.5

Table 3. *The dry weight of tobacco at various zinc concentrations.*

Conc. \ Part	Dry weight of shoot	Dry weight of root	Total dry weight of shoot and root
	gm	gm	gm
No Zn	8.68	1.32	10.0
0.025 ppm	14.3	1.85	16.15
0.151 ppm	23.1	4.9	28.0
1.250 ppm	17.3	2.7	20.0
2.505 ppm	12.75	2.25	14.0

Fig 1. showing tobacco growth at various zinc concentrations.

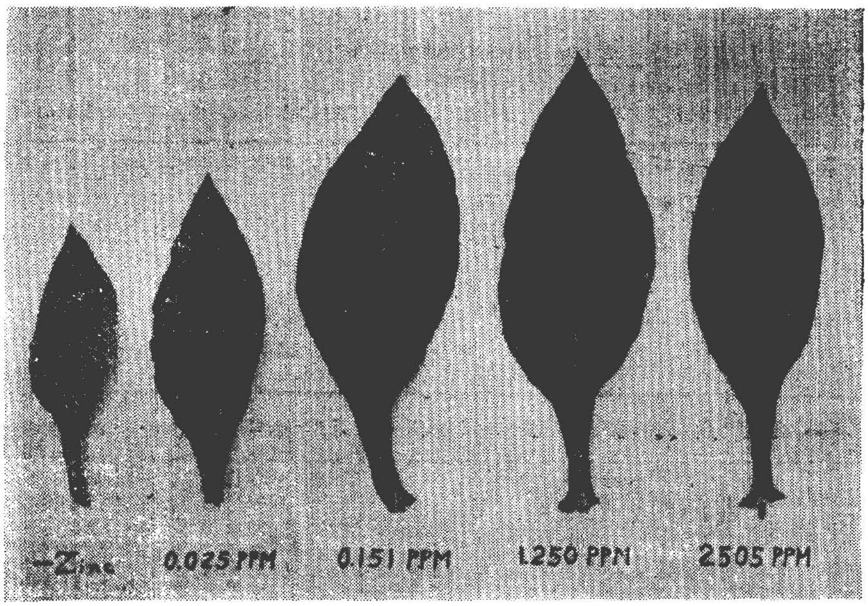

Fig 2. Comparison of tobacco young leaves growth at the same stage at various zinc concentrations.

B. Molybdenum series:

Tobacco seeds germinated on December 15. The seedlings were transplanted in various concentration of molybdenum around seven weeks from January 16, 1965 to March 3, 1965.

After seven weeks the plants presented many differences, dependent on molybdenum concentration in appearance (Fig 3; Table 4) and fresh, dry weight (Tables 5,6)

The records showed that the concentration of 0.06 ppm to be the best growth for tobacco. If molybdenum concentration reached to 0.50 ppm the growth was repressed, both fresh and dry weight were reduced.

Table 4. ***Shoot growth of tobacco at various molybdenum concentrations.***

Date \ Conc.	No Mo	0.011 ppm	0.060 ppm	0.502 ppm	1.002 ppm
	cm	cm	cm	cm	cm
16/1	1.05	1.10	1.05	1.05	1.05
23/1	3.0	2.95	3.5	3.35	2.9
30/1	3.1	3.7	4.8	3.9	3.05
6/2	3.15	4.05	8.1	4.25	3.10
13/2	4.0	5.5	16.25	7.25	4.10
20/2	10.0	12.0	25.5	16.0	10.5
27/2	15.5	25.0	39.5	32.0	19.5
6/3	24.5	37.0	52.5	50.1	29.5

Table 5. ***The fresh weight of tobacco at various molybdenum concentrations.***

Conc. \ Part	Freshweight of shoot	Fresh weight of root	Total fresh weight of shoot and root
	gm	gm	gm
No Mo	123.4	4.8	128.2
0.010 ppm	135.7	4.4	140.1
0.060 ppm	239.1	8.5	247.6
0.502 ppm	224.6	6.7	231.3
1.002 ppm	94.7	4.1	98.8

Table 6. ***The dry weight of tobacco at various molybdenum concentrations.***

Conc. \ Part	Dry weight of shoot	Dry weight of root	Total dry weight of shoot and root
	gm	gm	gm
No Mo	12.8	1.35	14.15
0.010 ppm	14.0	1.3	15.3
0.060 ppm	25.45	2.5	27.95
0.502 ppm	22.9	1.9	24.8
1.002 ppm	9.75	1.3	11.05

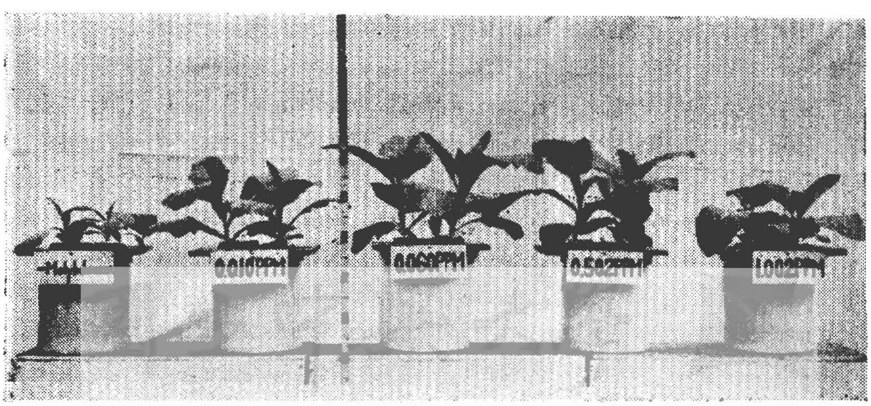

Fig 3. showing tobacco growth at various molybdenum concentrations after transplanting 3 weeks.

SUMMARY

Seven micronutrient elements were known to be essential for the growth of higher plants. The optimum concentration of each of the elements is that which is best for plant growth.

This study aimed at determining the best concentration of zinc and molybdenum, as was done (Yie 1964) for the iron, manganese and boron, and (Yie 1965) for copper and chlorine, for the growth of tobacco. Tobacco was cultured at various concentrations of micronutrient, zinc and molybdenum. The experiment repeated three times showed the same result each time, even in different seasons but the average temperature in the green house varied little (24°—28°C.)

The records showed that the concentration of zinc 0.151 ppm was the best for shoot growth and for the fresh weight and dry weight of both tops and roots of harvested tobacco. However the molybdenum requirement was found to be much lower than that of zinc, the result showing the concentration of molybdenum 0.060 ppm to give the best growth for tobacco.

In the case of zinc deficiency not only was there a decrease in shoot height but there was a lowering of fresh and dry weight. Zinc deficiency symptoms were observed in leaves and roots of tobacco. If the concentration of zinc was lower than 0.151 ppm, perhaps down to 0.025 ppm or higher than 0.151 ppm, perhaps up to 1.250 ppm, the shoot growth of tobacco decreased and fresh and dry weight were reduced.

In the case of the element molybdenum, the records showed that the concentration of 0.06 ppm was the best for shoot growth and the heaviest fresh, dry weight of both tobacco tops and roots. At concentrations of molybdenum lower or higher than 0.06 ppm the shoot growth was repressed and both fresh and dry weights of tops and roots were reduced. Chlorotic mottling symptoms were observed in tobacco leaves growth in a solution deficient in molybdenum.

REFERENCES

Arnon, Daniel I. 1954

Some recent advances in the study of essential micronutrients for green plants. VIII^e Congres International de Botanique

Arnon, Daniel I., Ichioka Patricia S., Wessel, G., Fujiwara, A. and J. T. Woolley 1955

Molybdenum in relation to nitrogen metabolism. I. Physiologia Plantarum Vol. 8

Hibbard, P. I. 1943

Comparative amounts of zinc extracted from soil by a chemical solvent and by plants. Soil Science, Vol. 56, No. 6

Hoagland, D. R. 1940

Water culture experiments on molybdenum and copper deficiencies of fruit trees. American Society for Horticultulture Science, Vol. 38

Hoagland, D. R. and D. I. Arnon 1940

Some problems of plant nutrition. The Science Monthly Vol. LXVII. No. 3

Ichioka, Patricia S. and D. I. Arnon 1955

Molybdenum in relation to nitrogen metabolism. II. Physiol. Plantarum Vol. 8

Johnson, C. M.. Pearson, G. A. and P. R. Stout 1952

Molybdenum nutrition of crop plants. Plant and Soil IV, No 2

Loneragan, J. F. and D. I. Arnon 1954

Molybdenum in the growth and metabolism of Chlorella. Nature, Vol. 174

Meagher, W. R., Johnson, C. M. and P. R. Stout 1952

Molybdenum requirement of leguminous plants supplied with fixed nitrogen. Plant Physiology, Vol. 27, No 2.

Reed, H. S. 1942

The relation of zinc to seed production. Jour. Agric. Res.

Wallace, T. 1958

The diagnosis of mineral deficiencies in plants. Chemical Publishing Co. Inc.

Yie Shi-Tho 1958

The comparative amounts of boron requirement for the growth of sunflowers and tomatoes. Journal of Agriculture and Forestry, Vol. 7

Yie Shi-Tao 1964

A study of the influence of micronutrients on the growth of sugar cane and tobacco. The Journal of Science and Engineering. Vol. I

Yie Shi-Tao 1965

A study of the influence of copper and chlorine on the growth of sugar cane and tobacco. The Journal of Science and Engineering Vol. 2.

鋅與鉬影響烟草之生長研究

易　布　道

摘　要

本試驗之目的測定數種不同濃度之鋅與鉬對煙草之生長關係，每一種元素對每一種植物均經三次反覆試驗，每次成雙培養結果，即令在不同之季節進行，所得之結果均屬一致，其平均溫度爲 24°～28°C，因臺灣夏季氣溫甚高，從七月至九月停止溫室試驗，故溫度之變化較有限。

筆者將鋅配成五種濃度作精細之水耕培養，依記載之結果鋅之濃度，以 0.151ppm 其植株之生長發育最佳鮮量與乾量均爲最高，較 0.151ppm 濃度高或低，則生長勢均將降低新鮮重量與乾量亦將減輕，倘缺鋅之供給者，植株矮小，葉片叢生 (Rosette)，葉片小而有皺紋，黃化且散布雜色斑點等生理症狀。如鋅濃度達 1.250ppm，則煙草植株生長受抑制，鮮量與乾量亦降低，濃度越大，害作用更顯著。

鉬之濃度 0.06ppm 對煙草之生長最有利，濃度低到 0.010ppm 或高到 0.502ppm，其生長勢與鮮量及乾量均減少。

據筆者 (1964, 1965) 及本次試驗結果，對煙草生長所需之七種必要微量元素，已得到其每一元素之最適生長之濃度，例如鐵與氯爲 2.50ppm，硼與錳爲 0.302ppm，鋅爲 0.151ppm，銅與鉬爲 0.06ppm，雖其需量極微，倘少於或多於此一最適微量，均能限制或阻碍煙草之生長與發育，是值吾人施肥時之參考。