PRELIMINARY STUDIES ON THE GROWTH OF TOMATO, EGG AND RADISH CROP PLANTS CULTIVATED IN A HIGH-HUMIC ANDOSOL AND ITS SUBSURFACE

Estudios Preliminares del Crecimiento de Plantas de Tomate, Berenjena y Rábano Sembradas en un Andosol Muy Húmico y en Su Subsuelo

Manoel Vicente de Mesquita Filho and Antonio Francisco Souza
Embrapa Hortaliças, C. P. 218, 780359-970, Brasília/DF
Email: mesquita@cnph.embrapa.br
Email: souza@cnph.embrapa.br)
Keiichiro Matsuda
Emeritus Professor of Faculty of Agriculture, Shizuoka University
Ohya, Shizyuoka 422, Japan

Palabras clave: *suelo volcánico, hortalizas, macro y micronutrientes.*

RESUMEN

Es muy difícil determinar precisamente los factores que afectan el pobre crecimiento de especies de plantas bajo condiciones ácidas, porque la acidez es una compleja interacción de muchos factores del suelo. El propósito de este estudio es delucidar cuáles factores predominantes son responsables por el pobre crecimiento de plantas de tomate, berenjena y rábano, sembradas en un Andosol muy húmico (HHA) y en su subsuelo (HHAS). Fué examinado que tipo de elementos podrían ser factores limitantes después de sembrar especies vegetales que fueron más ó menos afectadas por la la tolerancia a la acidez así como al Al y Mn. Fue comparada la tolerancia de estos tres vegetales al Al y Mn. Con todo, cuáles factores de la planta serían resposables por la reducción en el crecimiento de estos vegetales no está claro todavía. Se supone que la resolución de este problema será la base para definir parámetros fisiológicos de las plantas, asociado a la acidez del suelo.

SUMMARY

It is difficult to determine precisely factor affecting poor growth of plant species under acid conditions because acidity is a complex interactions among various soil factors. The purpose of this study is to elucidate predominant factors which are responsible for the poor growth of tomato egg and radish plants cultivated in a high-humic Andosol (HHA) and its subsurface (HHAS). It was examined what kind of element could be a growth limiting factors after cultivation of three crops which were more or less affected by acid tolerance and also by Al and Mn. Tolerance of these three crops to Al and Mn was compared. However, which plant factors is responsible for growth reduction of these crops is not clear. It is believed that the resolution of this problem will be the base for defining physiological plant parameter associated with soil acidity.

Index words: *volcanic soil, vegetable crop plants, macro and micronutrients.*

INTRODUCTION

Soil acidity limits plant growth due to elemental deficiency and toxicity (Matsuda *et al.*, 1976; Mesquita Filho *et al.*, 1982; Mesquita Filho and Miranda, 1984). Plant species and genotypes within species varied widely in tolerance to soil acidity (Yang et al., 2004). Since these factors may vary with the soil, analysis of major factors limiting plant growth in acid soils are important for soil improvement and crop selection.

The purpose of this study was to elucidate which limiting factors in soil solution extracted from a high-humic Andosol (HHA) and its subsurface (HHAS) are responsible for the poor growth of tomato, egg and radish plants cultivated on these soils.

MATERIALS AND METHODS

Chemical and physical carachteristics of the HHA and HHAS collected from an unfertilized area of Nihondaira-Japan, is showed in Table 1. The experiment was conducted under greenhouse condition using 1.1 and 1.2 L pots filled with HHA and HHAS respectively. The experimental design was a complete randomized block with three replication and eight treatment plots which consisted of a control plot containing: nitrogen, phosphorus, potassium, magnesium, molybdenum and boron, and seven plots eliminating one mineral element as a control were stablished (Table 2). Nitrogen, phosphorus and potassium were applied as NH_4NO_3, NaH_2PO_4 and K_2SO_4 respectively with 10 kg per 10 ares. Calcium and manganese were applied as $CaSO_4$ and $MgSO_4$ and with 25% and 12.5% CEC respectively. Molybdenum (1mg kg^{-1}) and boron (0.1mg kg^{-1}) were applied as $(NH_4)\ 6Mo_7O_{24}.4H_2O$ and borax respectively.

Tomato, egg and radish plants were used as indicator plants. Crop plants were harvested at 35, 37 and 35 days of growth for each crop, respectively, while in HHAS were 50, 58 and 48 days growth, respectively.

RESULTS AND DISCUSSION

Table 1 shows that the values of pH (H_2O) and pH (KCl) of HHA were 4.85 and 5.62. Its acidity (Y1) and the base saturation degree were 11.1 and 7.1%, respectively.T hese data show that HHA was a strongly acid soil (Matsuda *et al.*, 1976). The values of pH, Y1 and base saturation degree in HHAS were 5.62, 4.28, 1.6 and 17.7%, respectively, indicating that HHAS was having a lower acidity compared to HHA. The contents of humus and total nitrogen in HHA and HHAS were 9.58, 0.4 and 0.28 and 0.08, respectively. Exchangeable Ca and Na were not different in two soisl, but exchangeable K annd Mg were higher in HHA compared to HHAS soil. Clay contens of HHA and HHAS were 300 and 514 g kg^{-1} and soil texture of these soils were light clay (LC) and heavy clay (HC), respectively.

Poor tops and root growth of three crops on HHA under control and plot received complete elements are presented in Figure 1. The decrease in root dry wight was in order of -P<-Mo<-B<-Mg<-K,-N. Root dry weight of egg plants significantly decreased in plots of -K, -N, -P and –Mg. Radish growth was also decreased in the plot of -K, -Mg and -Ca.

Figure 1 also showed that in HHAS the growth in control plot of tomato plants increased more than that in the case of HHA. Growth of both tops and roots of tomato plants were lower in the order of each plot of -N, -P than the others. During the plant growth period, poor growth of tomato plants was observed in all plots of HHA. This reduction in growth may be associated with Al toxicity and P deficiency (Mesquita Filho *et al.*, 1982; Mesquita Filho and Miranda, 1984). High correlation coefficient between dry weight and aluminum contents of tomato plants was observed in HHA (Figure 2). From these results, it can be concluded that predominant factors of growth injury of tomato plants in HHA were aluminum toxicicity and phosphorus deficiency.

In Figure 1 it can be observed that the root growth of egg plants strongly decreased in plots of -N and followed by plots of -K and -Ca. Correlation coefficient between dry weight and aluminum (Figure 2) or manganese (Figure 3) contents of egg plants in HHA having low values. Hence, egg plants were supposed to have higher tolerance to aluminum or manganese toxicity in comparision to tomato plants. Foy et al (1973) found similar results on the studies of differential effects of aluminum on the vegetative growth of tomato cultivars in acid soils. The concentration of potassium, magnesium and calcium of radish plants showing low growth was observed in plots of -K, -Mg and -Ca in HHA. In Figure 1 it can be observed that growth of radish roots also decreased in plots of -N and -P in HHA. Predominant factors of growth injury of radish plants in HHA were thought to be due to potassium, magnesium and calcium deficiences. In HHAS, the concentration of nitrogen and phosphorus of tomato plants having low growth in plot in the order of -N<-P, respectively. Hence, predominant factors of poor growth of tomato plants in HHAS were nitrogen deficiency followed by phosphorus deficiency. Similary, predominant factors of both egg and radish plants were appreciated to be due to nitrogen and phosphorus defficiencies for poor growth in HHAS.

Tables 3 and 4 show dry weight indexes of tomato, egg and radish plants cultivated in HHA and HHAS with mineral elements. Growth response of plants in soil is being more sensitive for roots than the tops. Radish plants were noticed to have, on the whole, higher tolerance to HHA and HHAS of each plot than tomato and egg plants as shown in Table 5. Tomato plants were shown to be higher tolerance than that of egg plants in each plot of -N,-P and -K in HHA. However, as mentioned earlier, tomato plants are more susceptible to aluminum toxicity in comparision with egg plants in HHA. Hence, tomato plants were having lower tolerance to each plot of HHA than egg plants.

In HHAS, egg plants were considered to be lower in each plots of -N, -P and -Ca, and be higher in each plot of -K, -Mg, -Mo and -B than that of tomato plants. Frequently, toxic effects of aluminum and manganese occur simultaneously on high manganese soils. Both, aluminum and manganese are generally dissolved in acid soil and they are primary factors for the plant growth injury (Mesquita Filho *et al.*, 1982; Mesquita Filho and Miranda, 1984).

CONCLUSION

The difference in predominant elements introducing poor growth of three kinds of vegetable crops was found in HHA but not in HAAS.

REFERENCES

FOY, C.D.; CERLOFF, G.C.; GABELMEN, W.H. Diferential effects of aluminum on the vegetative growth of tomato cultivars in acis soils and nutrient solution. Journal of the American Society for Horticultural Science. Madison, 98 (5): 427-32.

MATSUDA, K.; KOBAYASHI, F.; MESQUITA FILHO, M. V. de. ; KONISHI, S. 1976. Studies on the acidity of tea plants caused by beavy application of ferilizer. Japan Society of the Science of Soil and Manure, pp. 22-65. (in japanese).

MESQUITA FILHO, M. V. de; MIRANDA, L. N. de. 1984. Avaliação de cultivares de soja para sua tolerância à toxidade de alumínio com relação à disponibilidade em fósforo em solo de cerrado. Ciência e Cultura 30: 175-80.

MESQUITA FILHO, M. V. de; MIRANDA, L. N. de; KLUTHCOUSKI, J. 1982. Avaliação de Cultivares de feijão para sua tolerânica à toxidade de alumínio com relação à disponibilidade de fósforo em solo de cerrado. Revista Brasileira de Ciências do Solo 6:43-46.

YANG, X,;WANG, W.,YE, Z., HE, A.; BALIGAR, V. C. 2004. Physiological and genetic aspects of crop plant adaptation to elemental stresses in acid soils. In: The red soils of China, ed. M. J. Wilson, Z. He and X. Yang, 171-218. Kluwer Academic Publishers, Dordrecht, The Netherlands.

ANEXOS.

Table 1. Chemical and physical properties of a high-humic Andosol (HHA) and in its subsurface (HHAS).

Soil physical and chemical property	HHA	HHAS
Depth (cm)	2 - 56	<88
pH (H_2O)	4.85	5.62
pH (KCl)	4.11	4.28
Y_1	11.1	1.6
C (g kg^{-1})	55.0	2.4
Humus (g kg^{-1})	95.2	4.2
N (g kg^{-1})	2.8	0.8
CEC ($mmol_c$ kg^{-1})	3180	1080
Ca ($mmol_c$ kg^{-1})	1300	1600
Mg ($mmol_c$ kg^{-1})	75	160
Na ($mmol_c$ kg^{-1})	12	12
K ($mmol_c$ kg^{-1})	13	8
V (%)	7.1	17.7
Mo (mg kg^{-1})	0.1	0.8
*B (mg kg^{-1})	0.6	0.2
Al in H_2O (mg kg^{-1})	0.2	0
Al in KCl (mg kg^{-1})	28.5	3.8
Mn in H_2O (mg kg^{-1})	2.7	0.8
Mn in KCl (mg kg^{-1})	26	18
Coarse sand (g kg^{-1})	26	80
Fine sand (g kg^{-1})	306	197
Silt (g kg^{-1})	368	209
Clay (g kg^{-1})	300	514

Table 2. Experimental plots.

Plot		Amounts of elements applied						
		N	P_2O_5	K_2O	Ca	Mg	Mo	B
			kg 10^{-1}a			% CEC		mg kg^{-1}
1	Control	20	20	20	25	12.5	1	0.1
2	-N	0	20	20	25	12.5	1	0.1
3	-P	20	0	20	25	12.5	1	0.1
4	-K	20	20	0	25	12.5	1	0.1
5	-Ca	20	20	20	0	12.5	1	0.1
6	-Mg	20	20	20	25	0	1	0.1
7	-Mo	20	20	20	25	12.5	0	0.1
8	-B	20	20	20	25	12.5	1	0

Table 3. Dry weights indexes of tomato, egg and radish plants cultivated in high-humic Andosol.

Plot	Tomato		Egg		Radish	
	Tops	Roots	Tops	Roots	Tops	Roots
Control	100	100	100	100	100	100
-N	84	52	60	13	49	103
-P	15	31	95	14	130	104
-K	47	51	77	11	105	61
-Ca	37	37	109	76	68	67
-Mg	39	49	64	39	90	62
-Mo	57	34	111	117	85	73
-B	50	41	88	88	82	94

Table 4. Dry weights indexes of tomato, egg and radish plants cultivated in high-humic Andosol subsurface.

Plot	Tomato		Egg		Radish	
	Tops	Roots	Tops	Roots	Tops	Roots
Control	100	100	100	100	100	100
-N	6	14	15	6	13	35
-P	18	25	12	6	5	34
-K	48	46	115	52	110	112
-Ca	29	63	139	53	103	177
-Mg	72	61	191	100	94	128
-Mo	79	65	126	73	82	146
-B	69	50	190	100	52	118

Table 5. Tolerance of tomato, egg and radish plants to high-humic Andosol and its high-humic Andosol subsurface.

	HHA		HHA subsurface	
	Total	Roots	Total	Roots
-N	R>T>E	R>T>E	R>E>T	R>T>E
-P	R>E>T	R>T>E	T>R>E	R>T>E
-K	R>T>E	R>T>E	R>E>T	R>T>E
-Ca	E>R>T	E>R>T	R=.E>T	R>T>E
-Mg	R>E>T	R>T>E	R=.E>T	R=.T>E
-Mo	E>R>T	E>R>T	R=.E>T	R>T>E
-B	R>E>T	R>E>T	E>R>T	E=.R>T

Fig.1 - Dry weight of three crops in high-humic Andosol and its subsurface.

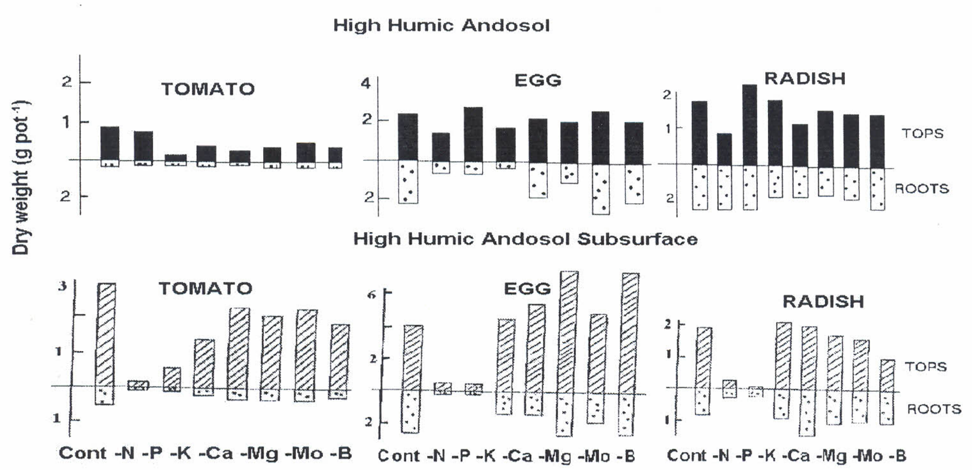

Fig.2 - Relationship between dry weight and aluminum contents of three kinds of crops in high-humic Andosol and its subsurface.

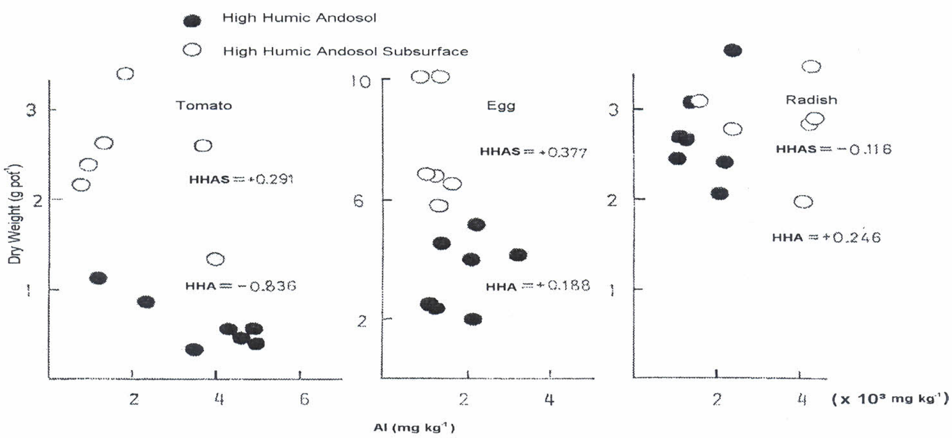

Fig.3 - Relationship between dry weight and manganese contents of three kinds of crops in high-humic Andosol and its subsurface.