THE USE OF AQUA AMMONIA FOR THE CONTROL OF SOIL BORNE DISEASES IN TOMATO

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ABSTRACT

The efficacy of aqua ammonia (NH_4OH, 28% N) for the control of nematodes and Fusarium and Verticillium wilts on tomato was studied in three greenhouse experiments grown in infected soil plots in Lebanon. Aqua ammonia (NH_4OH) was applied as diluted liquid in furrows and by a drip irrigation system at the rates of 50 (normal N fertilization rate), 75 and 100 mL m^{-2} (double N fertilization rate). Levels of control of aqua ammonia, applied as a single application before planting, were comparable to those of Agrocelhone (soil fumigant, mixture of Dichloropropene 55.4% + Chloropicrin 33.7%) achieved at a rate of 100 ml NH_4OH m^{-2}. Root galling in the control treatment was much higher than the other treatments. The yield and number of hairy roots of the control treatment were very restricted when compared to the NH_4OH and Agrocelhone treatments.

Keywords: root-knot nematodes, fusarium, verticillium wilt, soil fumigant, root galling index

INTRODUCTION

Root-knot nematodes (*Meloidogyne spp.*) and soil borne diseases caused by Fusarium and Verticillium pathogens occur worldwide and attack a wide range of crops. *Meloidogyne spp.* are generally polyphagous, and can attack different types of plant species, from grasses to trees, causing root galls. For this reason, the control of root-knot nematodes by crop rotation is limited. Methyl bromide, the most effective fumigant for the control of soil borne diseases and weeds, has already been banned in many countries in the world and it will be banned in Lebanon in 2015. Agrocelhone, a soil fumigant (mixture of 33.7% Chloropicrin and 55.4% Dichloropropene), is being used for the control of nematodes and other soil borne diseases in Lebanon, mainly in greenhouse agriculture. The use of Agrocelhone and other nematicides are expected to increase after the withdrawal of Methyl bromide from the Lebanese market in 2015. Ammonia is known to have a nematicidal effect (Havlin *et al.*, 2005). Much work has been done on the subject of injecting anhydrous ammonia (NH_3 gas, 83% N) or applying aqua ammonia (NH_4OH liquid, 28% N) to soil as a source of nitrogen fertilizer. The results led to a wide use of both materials in the United States, Russia and some

European countries. It was reported that ammonia mainly concentrates at 5 to 15 cm from the injection line, depending on soil texture, moisture and depth of injection (Eno, 1954). The research on ammonia and ammonium hydroxide retention in soil and its effect on soil microbial populations showed that the number of bacteria and fungi decreases sharply one day after the application and stays in low populations for several days or even sometimes weeks (Havlin *et al*., 2005). The reduction in the number of fungi suggests the possibility of using anhydrous ammonia as well as aqua ammonia as fungicidal and nematicidal agents in the soil. According to the litterature, this subject has never been previously investigated in Lebanon. The need for more information on this subject led to conduct this experiment to study the effect of aqua ammonia (NH_4OH) on the root-knot nematodes, Fusarium and/or Verticillium wilt infections on tomato. Objectives of this study were to investigate the effect of NH_4OH on the control of *Meloidogyne spp.*, *Fusarium spp*. and *Verticillium spp*., and on the yield response of tomato and compare the efficiency of NH_4OH to that of Agrocelhone, a widely used soil fumigant.

These three pathogens are considered the most economically harmful pests attacking vegetables and fruit trees in Lebanon and neighboring countries in the Middle East. Other products on the market, such as Metam sodium (Vapam), Dazomet (Basamid), Telone and Chloropicrin differ in their effectiveness in controlling soil borne diseases and their toxicity to the environment in general.

MATERIALS AND METHODS

Three experiments were conducted in three different greenhouses during the spring and summer seasons. Experiment 1 was conducted in the Antelias region (15 km North of Beirut), and experiments 2 and 3 in the Edde region (50 km North of Beirut).

Experiment 1

This experiment was conducted in a previously infected greenhouse with soil borne diseases to determine the efficacy of aqua ammonia (NH_4OH, 28% N) on nematodes, Fusarium and Verticillium wilts on tomato. A composite soil sample (0 – 25 cm deep) was collected randomly from eight points in the greenhouse prior to planting. The sample was air dried, ground, sieved and analyzed for its chemical and physical properties (Bashour & Sayegh, 2007). Tomato seedlings were germinated in seed trays and grown for two weeks in a greenhouse. Uniform seedlings were transplanted into a greenhouse which was known to be infected. This greenhouse has been planted with tomato and cucumber for several years without receiving any treatment to control the soil borne diseases. The design of the experiment was completely randomized design (CRD) with five treatments and three replicates. Each plot was 6 m long and 0.75 m row spacing. The application of aqua ammonia as diluted liquid in furrows was done one week prior to the transplanting of seedlings to the greenhouse. The rates of aqua ammonia used are shown in Table 1.

TABLE 1

Rates of NH_4OH of the Plastic Tunnel Experiment

Treatment Number	Treatment (mg kg^{-1})	Rate of NH_4OH per plot (mL m^{-2})
1	**400**	**100****
2	**200**	**50**
*3	**(200+200)**	**(50+50)**
*4	**(200+100)**	**(50+25)**
5	**CONTROL**	**CONTROL**

*Numbers in brackets: The first number is applied at pre-planting, and the second number is applied at 28 days post-planting.
**100 mL m^{-2}= double the N fertilization rate.

A soluble fertilizer (20-20-20 + TE) was applied to all plants at the same rate *via* fertigation, increasing gradually from 3g m^{-2} per week to 12 g m^{-2} per week during the harvest stage. The plants were drip irrigated throughout the growing season. Seventeen weeks after planting, the experiment was terminated. Soil samples were weekly collected from around the roots for nematode counts and evaluation of Verticillium and Fusarium infestations. Also, starting from the 6^{th} week after transplanting, one plant was removed from each plot for root galling (RGI) counts and disease evaluations. RGI was assessed on a scale of 1 to 5 as shown in Table 2.

TABLE 2

Assessment of Root Galling Index on Tomato Roots

Galling Index	Number of Galls on Root Canopy	Diameter of Galls (mm)
1	0 – Sparse	≤ 1
2	Sparce Galls	1 – 2
3	Non-coalescent Galls	2 – 3
4	Numerous Galls	3 – 4
5	Extremely Abundant Galls	>4

Source: Hussey and Janssen (2002).

Note: The Bearmann Funnel technique was used for nematode extraction and larvae separation. Mounts for nematode identification were prepared.

Experiment 2

This experiment was conducted in two greenhouses, different from the one in the first experiment. The procedure was similar to experiment 1 with a change in the method of application of aqua ammonia and also with a change in the treatments. The main objective of

this experiment was to compare the efficacy of Aqua ammonia to Agrocelhone, soil fumigant (mixture of 55.4% Dichloropicrine and 32.7% Chloropicrin). The use of Agrocelhone for the control of soil borne diseases is expected to significantly increase after the withdrawal of Methyl bromide from the Lebanese market in 2015. The three treatments in this experiment were: Agrocelhone (50 kg du^{-1}), Aqua ammonia (50 kg du^{-1}) and control. The same experiment was conducted in both greenhouses in the spring season. Observations were collected during the growing season and the yield was taken as an indicator of the efficacy of the treatments on soil pathogens.

Experiment 3

This experiment was a repetition of experiment 2. It was conducted in the same form in two nearby greenhouses during the summer season, to confirm the results of experiment 2. The yield was taken as an indicator for the efficacy of the treatments on soil pathogens and plant health.

RESULTS AND DISCUSSION

Experiment 1

The soil was clayey loam, slightly alkaline (pH of 7.3), non saline, calcareous ($CaCO_3$ – 60.6%) with sufficient levels of micro and macronutrients. During the season, results and severity of infections were estimated from isolations as shown in Table 3.

TABLE 3

Degrees of Infections in the Different Treatments

Treatment	Aqua ammonia (ml m^{-2})	Root Galling Index	Nematode	Fusarium	Verticillium
1	100	0.5	+	-	+
2	50	1.5	+ +	+	+
3	(50 + 50)*	2	+ + +	+ +	+ +
4	(50 + 25)*	1.2	+ +	+ +	+ +
5	Control	4.5	+ + + + +	+ + + +	+ + + +

*Numbers in brackets: the first number is applied at pre-planting, and the second number is applied at 28 days post-planting.

+ : low concentration
+ + : medium concentration
+ + + : high concentration
+ + + + : very high concentration
+ + + + + : extremely high concentration

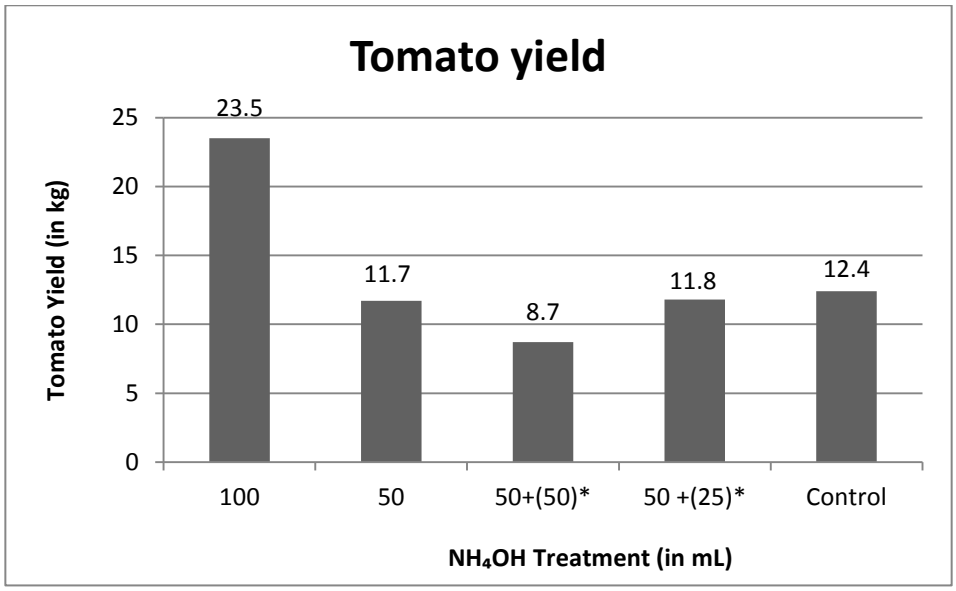
Plants amended with NH_4OH showed abundant growth as compared to the control treatment: this could be due to the higher N supply. NH_4OH also led to the reduction of root knot galling of tomato plants and to lower Fusarium and Verticillium disease incidences (Table 4 and Figures 1 and 2).

TABLE 4

Effect of Ammonium Hydroxide and Agrocelhone on Tomato yields in kg m^{-2}

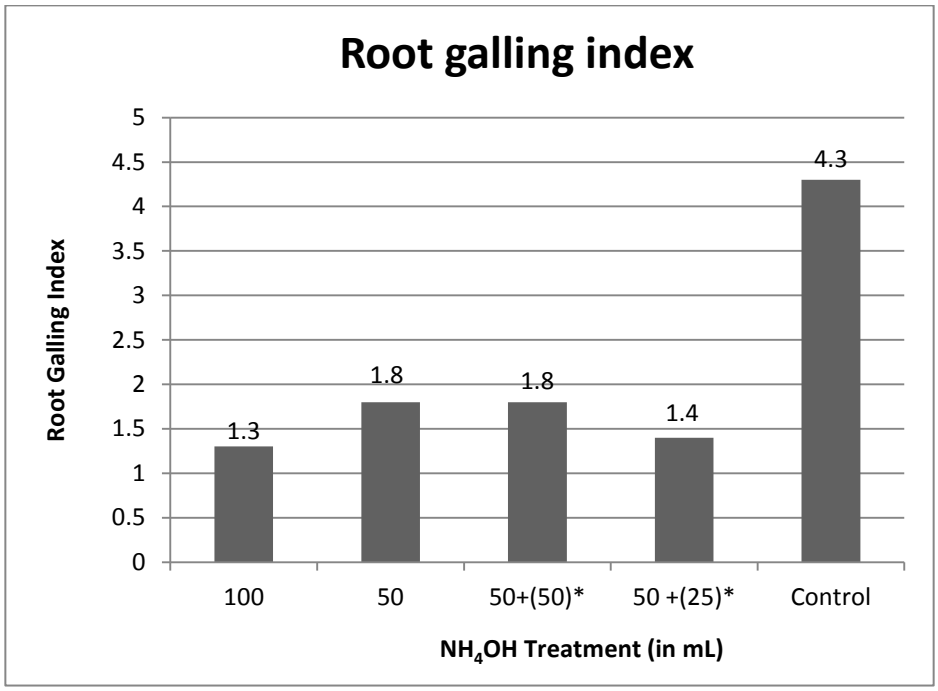
Planting Season	Control	NH_4OH (50 g m^{-2})	Agrocelhone (50g m^{-2})
Spring (1)	22.5	28.2	30.6
Spring (2)	26.4	33.7	33.0
Summer (1)	18.3	25.1	23.5
Summer (2)	19.1	24.4	25.2

Results show that Ammonium hydroxide at a rate of 100 ml of NH_4OH m^{-2} almost doubled the yield of tomato (Figure 1) and reduced RGI from 4.5 to 0.5 (Figure 2).



*Numbers in brackets: applied at 28 days post-planting

Figure 1. Effect of NH_4OH rates on the yield of tomato.



*Numbers in brackets: applied at 28 days post-planting

Figure 2. Effect of NH_4OH rates on RGI of the tomato root knot disease.

The pre-planting application of NH_4OH was found to be more effective than the post-planting application. Actually, it is recommended to only apply NH_4OH pre-planting because of its toxic effects on live tomato plants when applied during the growing season. The best results were obtained when NH_4OH was applied pre-planting at a rate of 100 ml m^{-2}.

Experiments 2 and 3:

The observations obtained from experiments two and three are the following:

- *Control treatment:* The root system was highly restricted. The small hairy roots were rare and infections with *Rhizoctonia solani* and root knot were also common.
- *Ammonium Hydroxide:* At the early stages of the experiment, the plants were greener in color than plants in the other two treatments which showed some chlorosis symptoms. The root system was stronger than that of the control treatment and smaller than that of Agrocelhone treatment. The small hairy roots were medium in size and only moderate infection with root rot was observed.
- *Agrocelhone:* The root system was well extended. The small hairy roots were stronger than in the other two treatments. Infections with root-rot were limited.

CONCLUSION

Limited research has been done in Lebanon on the control of soil borne diseases, root-knot nematodes, and Fusarium and Verticillium wilt on tomato using these methods. As a first field study on the subject, the following may be concluded. The application of NH_4OH, pre-planting, at a rate of 100 ml m^{-2} was effective in reducing root infections by nematodes, Fusarium and Verticillium wilts, and also on increasing yield. The application of Agrocelhone prior to planting was also effective in the control of the studied soil borne diseases. This subject is newly studied in Lebanon, and is worthy of more detailed investigations.

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