SYMPTOMS AND DIAGNOSIS OF AMMONIUM TOXICITY IN CHRYSANTHEMUM

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Ammonium (NH_4) toxicity may occur for several reasons; however, these are two principle causes. When large quantities of readily decomposable organic matter such as manure or peat humus are incorporated into the soil and then sterilized a rapid release of ammonical nitrogen usually follows. If heavy watering is not practiced a critical level of NH_4 will build up. A second cause stems from the continual use of ammonical fertilizers such as ammonium sulfate, or fertilizers such as ureaformaldehyde which generate NH_4.

The symptoms of NH_4 toxicity are numerous and many of them coincide with symptoms of other disorders. The symptoms can also vary with the type of plant. Because of the difficulty in diagnosing NH_4 toxicity visually and the lack of foliar analysis standards this study was undertaken.

The treatments tested in this study were based on previously known relationships between potassium (K), pH and NH_4 toxicity. Increasing levels of K result in greater conversion of NH_4 within the plant to amino acids and protein. Thus, the chance of building up a toxicity level of NH_4 in the plant is reduced if an adequate or slightly above adequate (but not toxic) level of K is supplied to the plant. Increasing soil pH also alleviates the problem of NH4 toxicity. As soil pH rises increasing quantities of ammonical nitrogen change over to gaseous ammonia and is lost from the soil. There is also an antagonistic effect of calcium, associated with higher soil pH levels, upon the uptake of NH_4 by the plant.

Methods

Three experiments were conducted to test 2 varieties of pot mums and 2 seasons of the year.

Rooted cuttings of the chrysanthemum variety Bright Golden Anne were planted 5 per 6-inch pot on January 12, 1970. The soil mix consisted of equal parts soil, coarse sand and sphagum peatmoss amended with 4 oz. of dolomitic lime and 2 oz. superphosphate per cu. ft. Plants were pinched back on January 26. One week of long day treatment was applied. On February 9 the plants were sprayed with a 2500 ppm solution of B-Nine to control height. Temperatures were maintained in the greenhouse at 60^oF during the night and 70-75^oF during the day when season of the year permitted.

Sixteen treatments applied to 3 pots of plants in each of 2 replications consisted of all combinations of 4 levels each of NH_4 supplied as ammonium sulfate at rates of 18, 35, 70 and 140 ounces per 100 gallons and K supplied as potassium chloride at rates of 0, 10, 30 and 60 ounces per 100 gallons. Fertilizer solutions were applied weekly beginning 3 days after planting.

The first fully expanded leaves (15 g if possible from each group of 3 plants) were sampled 2, 4, 6 and 8 weeks after planting. The 8 weeks sample was collected 2 weeks prior to crop maturity. The 2 and 4 week samples were collected from the primary shoot, while the latter 2 samples were collected from secondary shoots. A portion of each sample were analyzed for NH_4 content and the remaining portions for K and both determinations reported as concentrations based on the fresh weight of leaves sampled (milliequivalents/100 grams fresh weight). Previous researchers have reported that the ratio of NH4 to K is better indication of NH_4 toxicity than the NH_4 level alone. For this reason NH_4/K ratios were studied as the criterion of NH_4 toxicity in these experiments.

A second experiment was established on June 2, 1970 to test a different pot mum variety, Yellow Mandalay, during a summer season. Fertilizer treatments were modified to bring all treatments closer to the critical NH_4/K ratio. All combinations of ammonium sulfate at 18, 35, 70 and 105 ounces per 100 gallons and potassium chloride at 5, 10, 30 and 60 ounces per 100 gallons were tested. Cultural procedures were the same as in the first experiment and samples were again collected 2, 4, 6 and 8 weeks after planting.

The third experiment was designed to duplicate the first experiment. The chrysanthemum variety Bright Golden Anne was planted December 10, 1970, pinched and subjected to short day treatment December 29 and treated with B-Nine for height control on January 12. This experiment was replicated 5 times with 3 pots per plot. Nine fertilizer treatments consisting of all combinations of 18, 35 and 70 ounces of ammonium sulfate and 5, 10 and 30 ounces of potassium chloride per 100 gallons were applied weekly. These treatments were selected to insure a large proportion of tissue NH_4/K ratios around the critical range since it was only this range of ratios under question in this study. Samples were taken 2, 5 and 8 weeks after planting. All other cultural and analytical procedures were similar to the previous experiments.

Results

All plants treated with the lowest level of K regardless off ammonical N level showed signs of K deficiency. Symptoms included reduced leaf and plant size and necrosis of margins on lower leaves. Nitrogen deficiency symptoms consisting of mild reduction in plant size and uniform light green lower foliage was apparent on all plants treated with the lowest level of ammonium regardless of K level. An additional set of symptoms, those of ammonium toxicity, occured in the high ammonium N treatments and were intensified by decreasing K levels. Symptoms of NH_4 toxicity in order of occurrence were:

1. Reduction in growth rate of the plant.

2. Irregular chlorosis on leaves halfway down the plant sometimes tending to be interveinal.

3. The occurrence of 1/16-inch necrotic spots on the same leaves as above (Fig. 1).

4. Leaves become abnormally thick and leathery (Fig. 2).

5. Wide patches of necrosis first along the mid-rib toward the base of the leaf blade and eventually over the entire leaf. The leaves halfway down the stem are affected first (Fig. 3).

6. Root death.

7. Death of entire plant.

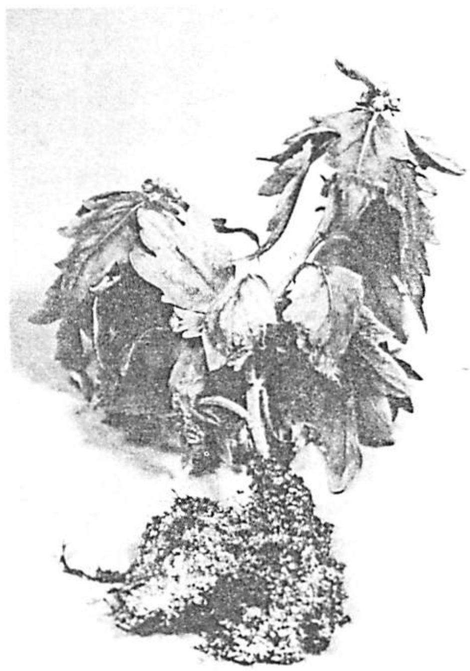

Fig. 1. Symptoms of NH4 toxicity including stunted growth, chlorosis, necrotic leaf spots and root injury.

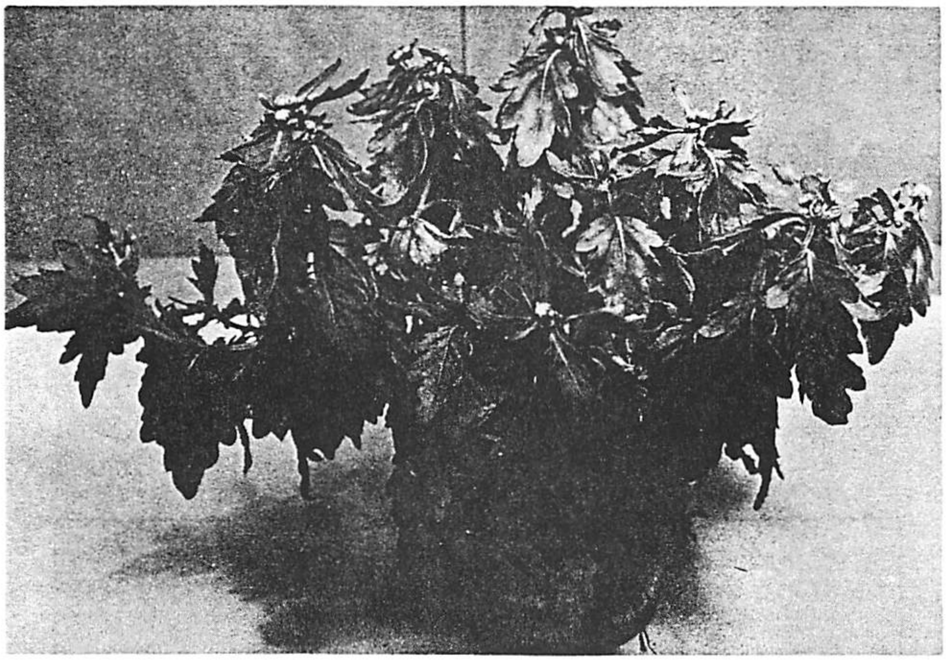

Fig. 2. Abnormally thick and leathery leaves due to NH_4 toxicity.

Fig. 3. Symptoms of the late stages of NH_4 toxicity including stunted growth, chlorosis and extensive death of foliage.

The critical NH_4/K ratio was selected by plotting for each sample date of each experiment the highest ratio associated with normal plants and the lowest ratio at which toxicity symptoms appeared (Fig. 4). These data indicate that all ratios of 0.026 (2.6 units of NH_4 per 100 units of K) and greater were associated with toxicity symptoms while all ratios of 0.025 or lower were associated with normal plants. Within the range of 0.025 and 0.026 some plants were injured and others were not. Due to errors inherent in sampling and in foliar analysis the critical range should be taken to be 0.022 to 0.029. Thus a ratio of 2.2 units of NH_4 per 100 units of K in the first fully expanded leaves of pot mums indicates that NH_4 toxicity is eminent and that corrective measures should be taken.

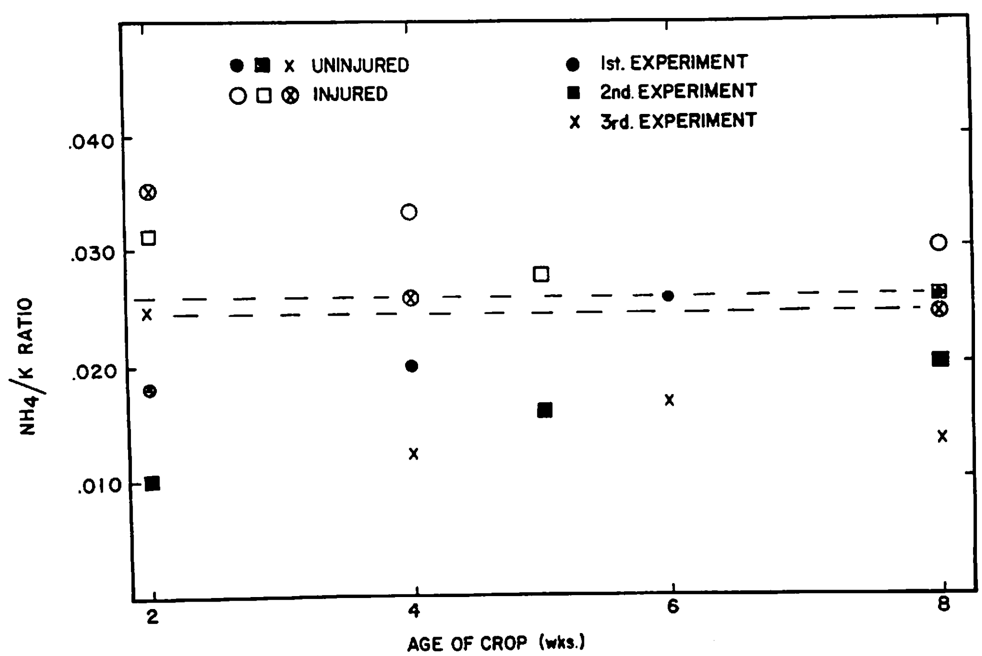

Fig 4. The NH_4/K ratios of fresh chrysanthemum leaf tissue closest to the critical ratio for each sampling date within each experiment. The critical zone is within the 2 horizontal lines. All values above this zone are associated with injured plants whereas those below the zone are associated with normal plants.