CALCIUM CHLORIDE EFFECTS ON NITROGEN UPTAKE BY SMALL GRAINS[+]

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ABSTRACT

Applying calcium chloride ($CaCl_2$) with urea stimulated nitrogen uptake by small grains in six greenhouse studies. The effect was most dramatic for a sandy soil, moderate for a loam soil, and not observed for a clay soil. Allowing the urea to nitrify before plant uptake negated the $CaCl_2$ effect. In field studies, these effects were generally not observed, probably because the nitrification of the applied N was too rapid. However, this concept deserves further investigation, for example, when established crops are sidedressed or perhaps with "point injection."

INTRODUCTION

The search to improve crop utilization of nitrogen (N) fertilizer continues. Much progress has been made. Advancements like pre-plant or pre-sidedress nitrate tests, better appreciation of the value of legume contributions, and split fertilizer applications have all contributed to better crop N utilization. One theory that has not been widely evaluated is the use of added calcium (Ca) to stimulate N uptake by crops.

Viets (1) showed that addition of divalent cations like Ca or Mg to nutrient solutions stimulated the uptake of monovalent cations like K. In a later series of papers, Fenn and co-workers (2, 3, 4) suggested that co-fertilization with Ca and ammonium can lead to substantial growth responses and increases in N uptake. Fenn has attributed these responses to the "Viets effect" of divalent cations on monovalent cation uptake.

Only a few field evaluations of these concepts have been found. Fenn and co-workers banded urea versus urea + $CaCl_2$ solutions on 1 m centers for radish (2), onion (3), and beets (4), and found stimulation of crop yields by the addition of $CaCl_2$ in each case.

The purpose of these trials was to determine whether $CaCl_2$ would stimulate N uptake by small grains in the

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greenhouse and whether these principles could be observed in the field.

METHODS

Greenhouse

We measured short-term N uptake by crops by the procedure of Stanford and co-workers (5, 6). In this method, small grains are grown in sand with all nutrients, except N, for 2 weeks. After 2 weeks the bottom of the pots are removed and the plants and sand transferred to soil treated with nitrogen (as urea) and Ca (as $CaCl_2$). The roots grow rapidly into the soil and nutrient uptake is intense. After different uptake periods, the tops of the plants were harvested, dried, and analyzed for total N. Thus, the greenhouse studies evaluated the ability of rapidly proliferating roots to extract N from freshly-fertilized soil. The soils used were a Vebar sandy loam (pH 6.5), Hammerly loam (pH 7.8, slightly calcareous), and Fargo clay (pH 7.8, slightly calcareous).

Field

Four sites were chosen on the basis of low in profile nitrate in the fall of 1993. Two sites were on clay soils, two on loamy soils. All soils had a pH > 7. Nitrogen rates were 0, 50, or 100 kg N/ha as urea, urea + $CaCl_2$ or urea + KCl. The urea solution was 20-0-0 and the urea-$CaCl_2$ solution was a commercial 23-0-0-7 solution. The KCl was broadcast and incorporated to rates to equal the Cl applied in the urea + $CaCl_2$ treatments. The urea or urea + $CaCl_2$ solutions were banded about 4 inches deep on 6 inch centers 1-2 d before planting 'Butte 86' spring wheat. The bands were sampled 4 weeks after fertilization to monitor the progress of nitrification. Nitrogen uptake and crop development were determined at the 4 and 7 leaf stages and straw and grain yield and N uptake was measured at maturity. Not all data are available at the time of this writing.

RESULTS

Greenhouse

Six greenhouse studies were performed. Space does not permit a complete presentation of all of the findings, so only the high points will be shown here.

Adding $CaCl_2$ to urea increased N uptake by barley in the first trial (Figure 1). Urea was added to 200 g of soil at 20 or 40 mg N/pot and Ca was added at a urea:Ca mole ratio of 1:0.25 (7 or 14 mg Ca/pot). The soil was a Hammerly loam. Averaged across N rate and days of uptake, adding $CaCl_2$ to urea increased apparent N recovery in the

tops by 8% (32 vs 40% of fertilizer N found in the barley tops).

The effect of $CaCl_2$ on N uptake by spring wheat was strongly influenced by soil type. The effects were relatively strong when $CaCl_2$ and N were applied together to a Vebar sandy loam (Figure 2), but no effect of $CaCl_2$ was observed with a Fargo clay soil. An intermediate response was observed with the Hammerly loam soil (data not shown).

Allowing the urea to nitrify before crop uptake seemed to vitiate the $CaCl_2$ effect. Urea (40 mg N/pot) versus urea + $CaCl_2$ (14 mg Ca/pot) were applied to the Hammerly soil. The fertilizer was either allowed to nitrify for 2 weeks or applied immediately before crop uptake. After 7 days of uptake, $CaCl_2$ stimulated the uptake of N from the freshly-fertilized pots, while uptake was not stimulated when the N was allowed to nitrify before crop uptake (Figure 3). This suggests that $CaCl_2$ will stimulate NH_4^+ uptake, but not NO_3^- uptake.

In our greenhouse trials, the effect of adding $CaCl_2$ to urea could often be detected visually. Normally, the N-deficient plants greened up more quickly when fertilized with urea + $CaCl_2$ versus urea alone and sometimes the darker green color persisted for up to 2 weeks.

Field

Only a brief summary of the field trials is given here. Fertilizer band samples taken 4 weeks after fertilization indicated very rapid nitrification. At all sites, it was estimated that 90-100% of the applied N had nitrified in four weeks (data not shown). When averaged across all sites, there was little influence of banding $CaCl_2$ with urea on N uptake by wheat plants at the 4 and 7-leaf stages (Figure 4). There may have been a stimulation of N uptake at the 7-leaf stage at one site (Figure 5).

July was very wet and foliar and head disease (scab) levels were far higher than normal. Averaged across all sites, there was little effect of banding $CaCl_2$ with urea, although there was a trend for a yield increase at one site (Figure 6).

DISCUSSION

There should be little doubt that adding $CaCl_2$ to urea can stimulate nitrogen uptake or growth of crops under some conditions. This has been shown in Fenn's studies (2, 3, 4), in our greenhouse studies and in other studies. The reason for these responses is open to some debate. Three possible explanations can be proposed: 1. Calcium enhances the rate of ammonium uptake, 2. Calcium displaces ammonium

from the exchange, speeding the kinetics of ammonium uptake simply because more is in the soil solution, 3. Calcium enhances the salt and ammonia tolerance of roots growing in freshly-fertilized soil. Interactions with chloride are possible when $CaCl_2$ is used. It might not be easy to define the exact reasons for these responses.

Unfortunately, achieving the conditions in the field for these responses might not be easy in some cropping systems. The band spacing in Fenn's field trials was very wide (1 meter) and nitrification could have been very slow, allowing for the $CaCl_2$ to stimulate uptake. In our field trials we used a 6-inch band spacing, nitrification was very rapid, and there was no effect of $CaCl_2$. It would be interesting to know if adding $CaCl_2$ to a more concentrated band for an established crop would have any agronomic benefits. Examples of this might be "point-injection" or sidedressing established crops like corn.

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Figure 1. Fertilizer N accumulation in barley tops as influenced by urea or urea + $CaCl_2$ fertilization. Greenhouse experiment, North Dakota 1994. Urea:Ca mole ratio was 1:0.25.

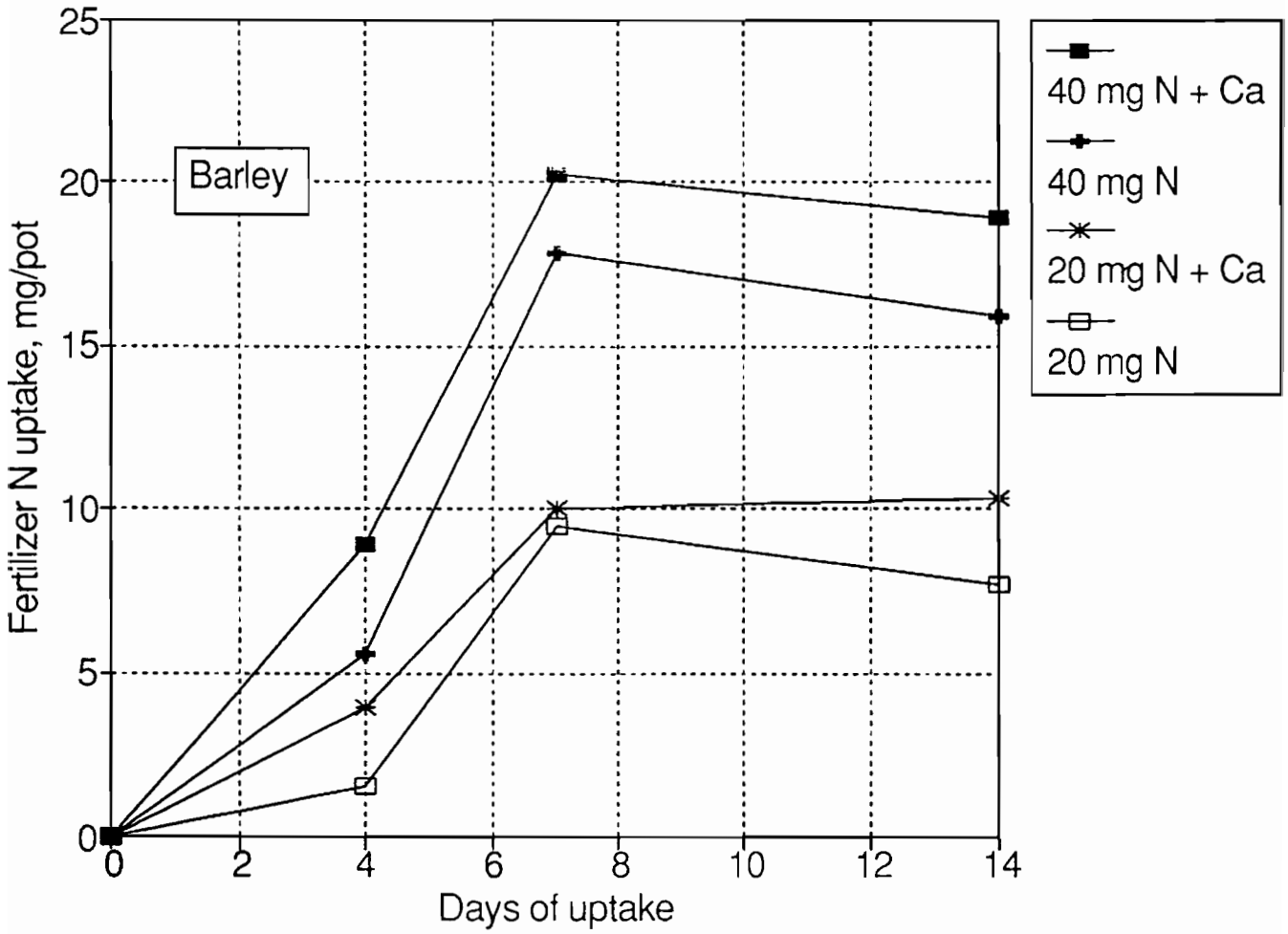


Figure 2. Effect of rate of $CaCl_2$ on fertilizer N accumulation in wheat tops. The two soils were a Vebar sandy loam and a Fargo clay. Nitrogen rate was 40 mg/pot.

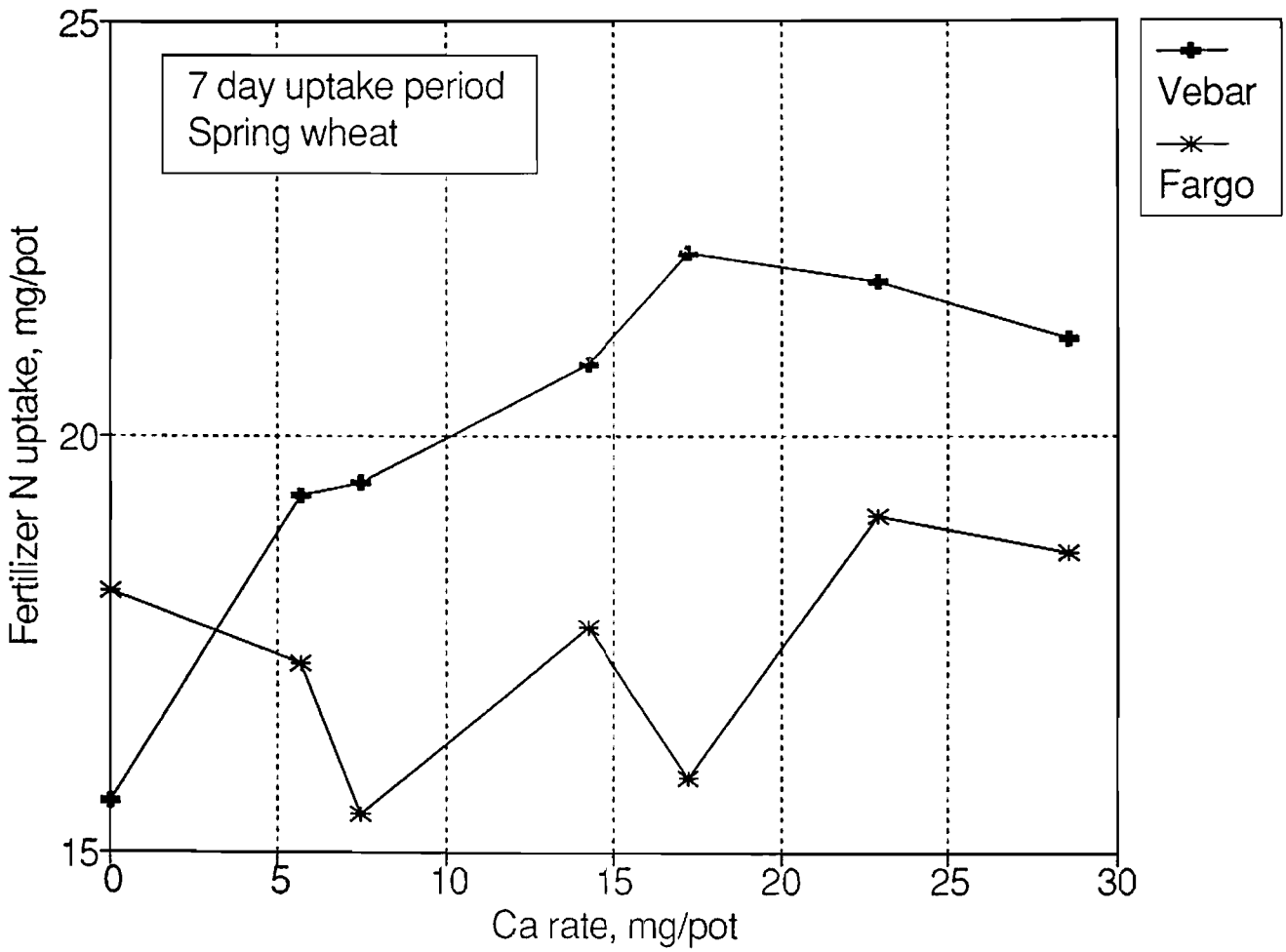


Figure 3. Effects of urea, urea + $CaCl_2$ and two weeks preincubation (PI) on fertilizer N accumulation in wheat tops. Nitrogen rate was 40 mg/pot, calcium rate was 14 mg/pot.

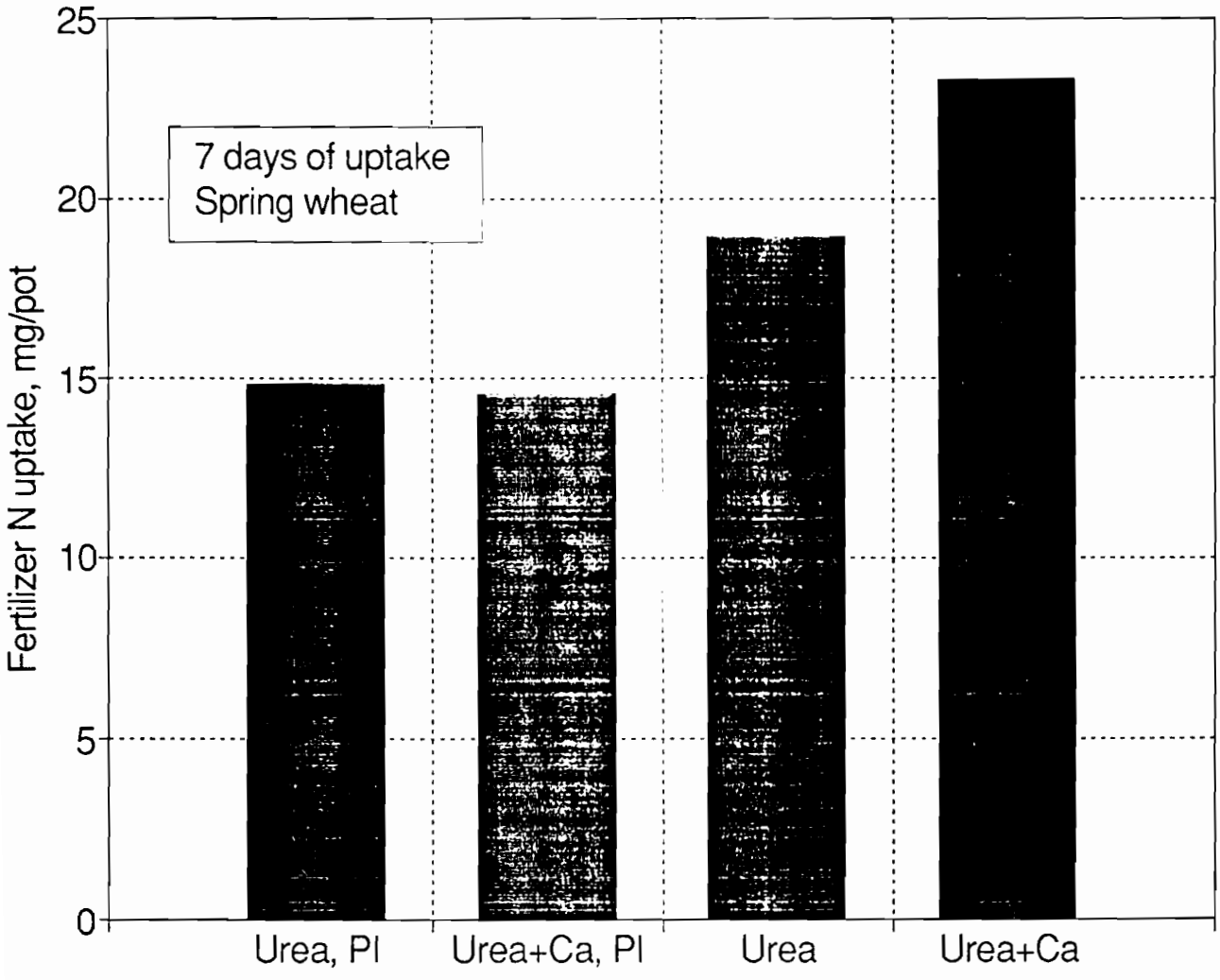


Figure 4. Effect of urea or urea + $CaCl_2$ on the N content of wheat tops at about the 4 and 7 leaf stage. Nitrogen rate was 100 kg/ha as urea, Ca rate was 30 kg/ha as $CaCl_2$. Four site average, ND, 1994.

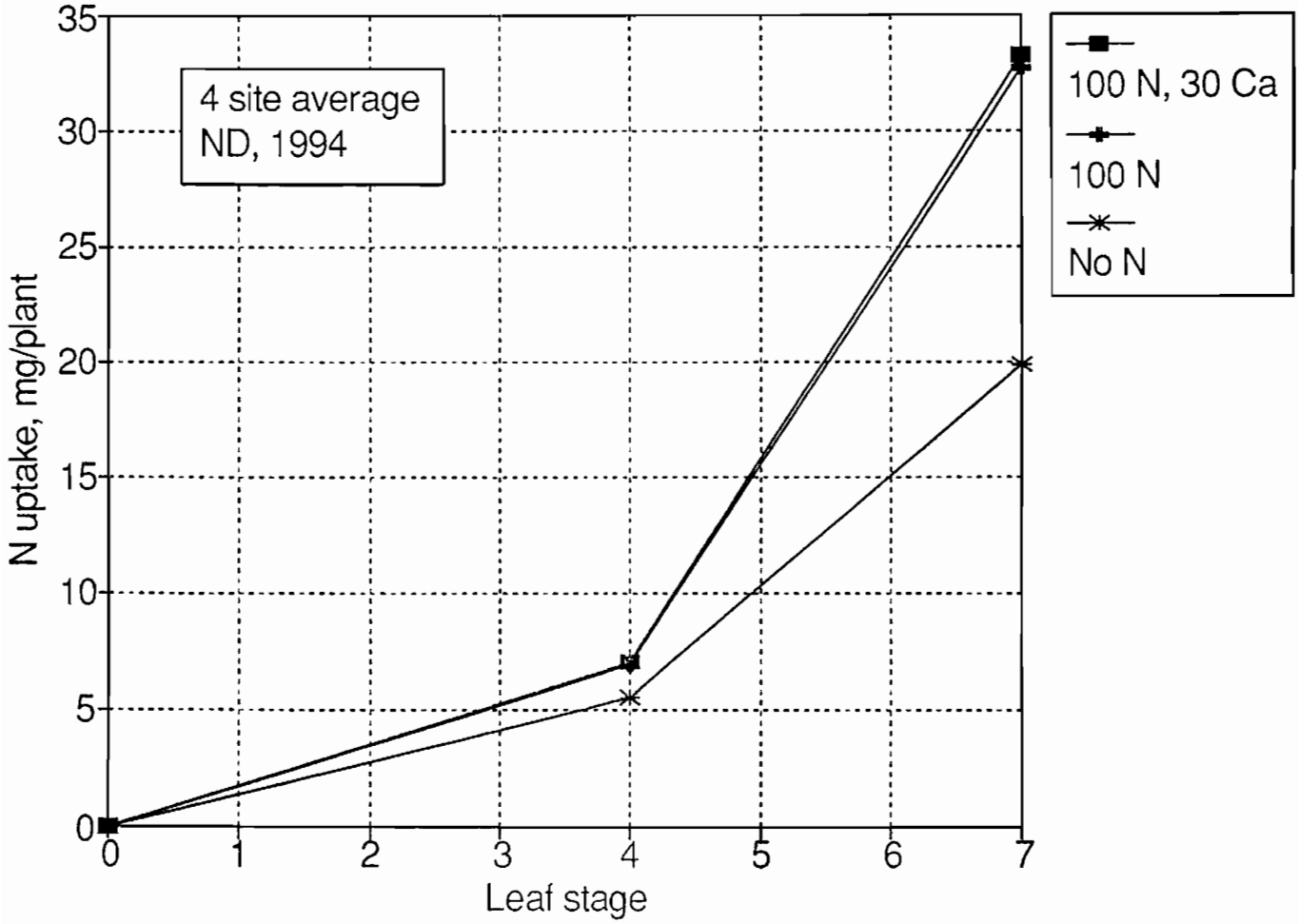


Figure 5. Effect of urea or urea + $CaCl_2$ on the N content of wheat tops at about the 4 and 7 leaf stage. Nitrogen rate was 100 kg/ha as urea, Ca rate was 30 kg/ha as $CaCl_2$. Galesburg, ND, 1994.

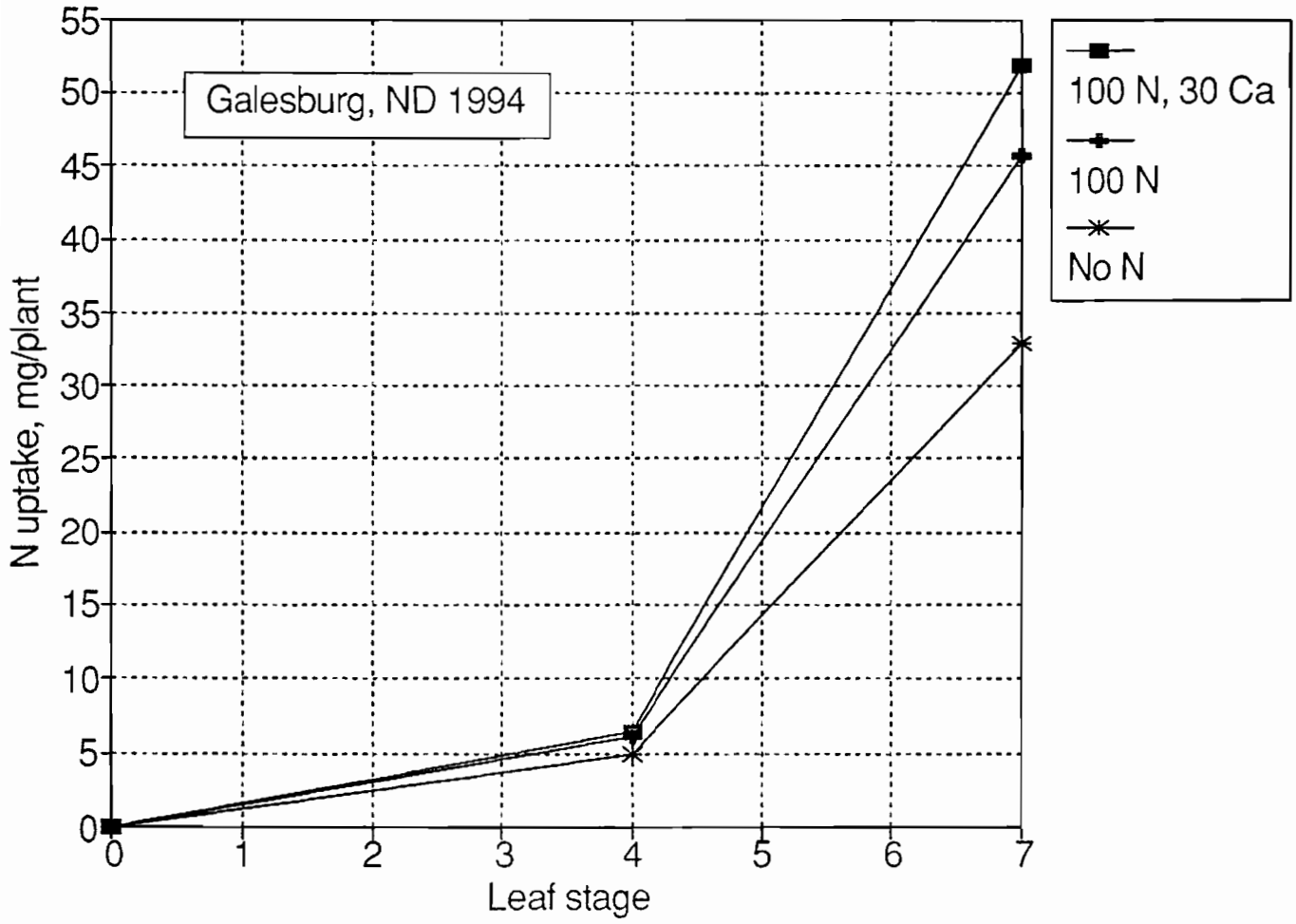
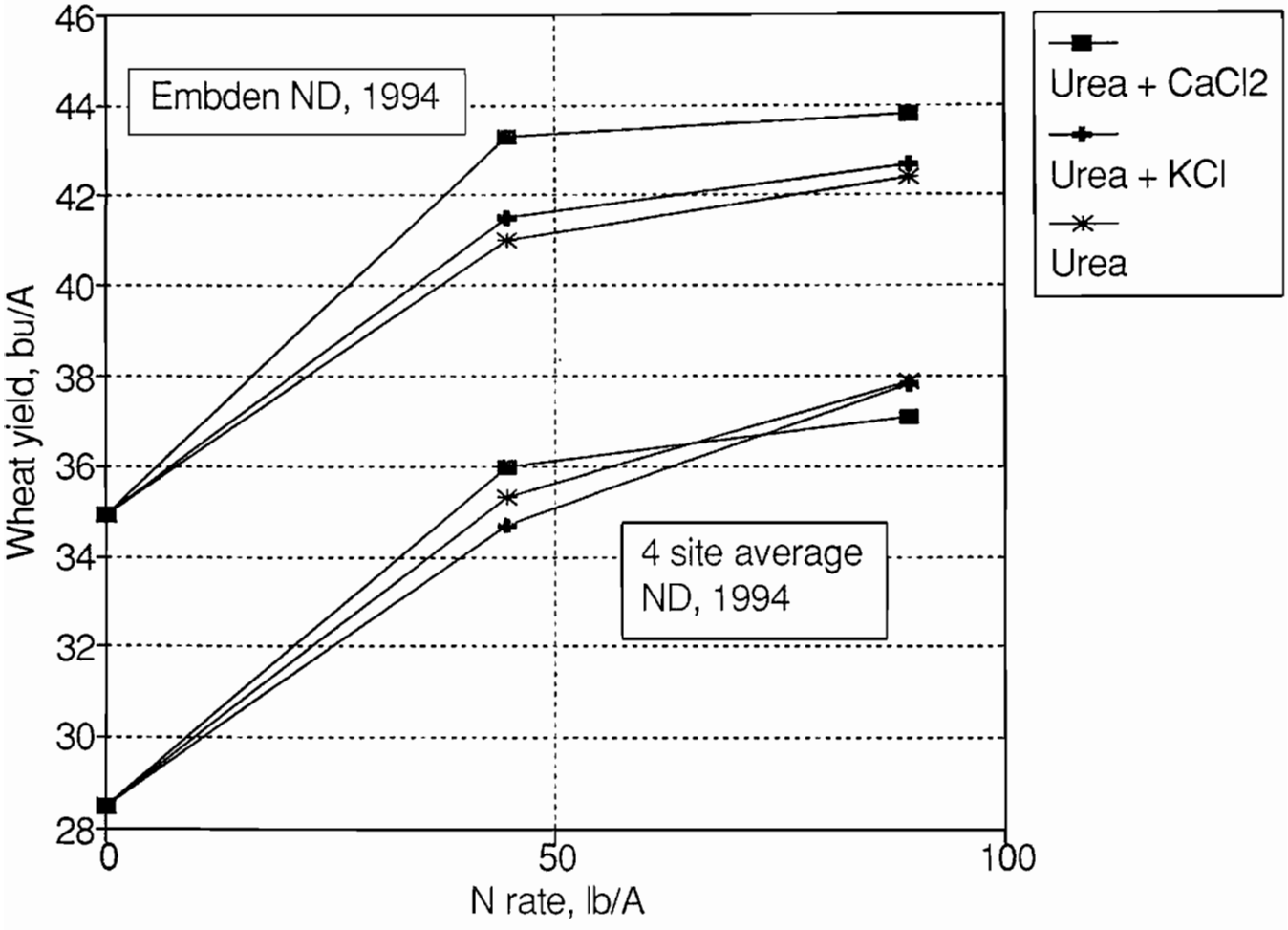


Figure 6. Effect of urea, urea + KCl, and urea + $CaCl_2$ fertilization on wheat yields. Embden, ND and a four site average, ND, 1994.



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