2-1-1962

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BULLETIN 640 FEBRUARY 1962

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Summary

Field experiments on applying nitrogen to cotton leaves have been completed recently by the Experiment Station.

In contrast to soil application, foliar feeding of nitrogen to cotton during the fruiting period does not appear to be practical, even though moderate nitrogen deficiency may be corrected by spraying frequently with dilute nitrogen solutions, particularly urea.

Urea should not be applied to the foliage just to provide insurance against nitrogen deficiency, because yields may be reduced if additional nitrogen is not needed.

Solutions containing ammonium nitrate are considered unsatisfactory for foliar application to cotton. Even at low concentrations, they burn the leaves and the nitrogen is not utilized efficiently.

Biuret, in amounts commonly found in fertilizer grade urea, was not toxic to cotton when applied to the urea solution (3%N).

FOLIAR APPLICATION OF NITROGEN TO COTTON

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Most studies on fertilizing of cotton with nitrogen in Mississippi have considered only soil application. As a result, there is a great deal of information on the effectiveness of this practice, but very little on foliar application. Accordingly, a study was begun in 1958, to determine the response of cotton to nitrogen solutions applied to the foliage in July and August. This was compared to the response obtained from a similar amount of nitrogen applied as a side-dressing between June 15 and July 1. Leaf injury or burn, as affected by solutions of varying concentration, also was studied.

Field experiments were located (1) at the Central Station on Kaufman fine sandy loam and on Leeper-Tuscumbia clay loam (2) at the Black Belt Branch Station on Houston clay, (3) at the Brown Loam Branch Station on Falaya silt loam, (4) at the Pontotoc Ridge-Flatwoods Branch Station on Atwood fine sandy loam, and (5) at the North Mississippi Branch Station on Grenada silt loam.

The main treatments were a check, foliar applications, and a sidedress application of nitrogen. They were arranged either in a randomized complete block or a Latin Square design with a minimum of five replications. In all the tests, adequate amounts of phosphorus and potassium together with a small amount of nitrogen were applied uniformly to all plots prior to planting each year. Each plot consisted of four rows 32 feet long. The sidedress applications of nitrogen were placed in the soil along the side of the row at the conventional time for this practice.

Foliar application usually was begun the first week in July, the nitrogen solutions being sprayed on the foliage of the cotton with a small compressed-air, garden-type sprayer. To aid in uniformity, the volume of solution to be applied to each plot was divided equally and applied separately to two rows of the plot. The rate of application was usually about 20 gallons per acre. Solutions containing 3% nitrogen were applied at weekly intervals while solutions containing 5% or 6% nitrogen were applied at bi-weekly intervals. With urea-ammonium nitrate and ammonium nitrate solutions, the concentration of nitrogen was 3%, but with urea solutions, the concentration varied from 3% to 6% nitrogen.

Details of the rates and frequencies of foliar applications are given in Table 1.

The fruiting period was chosen for foliar application because during this period cotton utilizes a relatively large proportion of the total nitrogen needed for the crop, while at the same time there is sufficient leaf surface to hold a substantial volume of liquid either as droplets or as a surface film. However, since only solutions of low nitrogen content can be applied without excessive injury to the leaves, the rate of nitrogen per application is somewhat limited.

Leaf Burn

When a solution of ammonium nitrate containing 3%N was applied to the foliage at the rate of 5 pounds of nitrogen per acre per application, the leaves were burned severely which stunted the growth of the plants and reduced the yield. Therefore, the ammonium nitrate solution was omitted from further studies after the first year.

An urea-ammonium nitrate solution containing 3% nitrogen (such solutions as uran and N-Sol 32 contain 32% N) caused noticeable leaf-burn when sprayed on the foliage at the rate of 5 pounds of nitrogen per acre per application. Consequently, urea-ammonium nitrate solutions of higher nitrogen content were not tested. Burning of the leaves by the urea-ammonium nitrate solution was expected because one-half of the nitrogen in this

solution was derived from ammonium ni trate.

Solutions of urea containing 5 to 6% of nitrogen caused some burning when sprayed on the foliage. but it was not as severe as with the urea-ammonium nitrate as with the urea-ammonium ni nitrate solution (3%N). A solution of urea containing 3% nitrogen did not appear to burn the leaves appreciably. Although as will be discussed later, spraying cotton frequently with such a solution apparently reduced the yield where there was an adequate amount of available nitrogen in the soil.

Yields

Yield results are summarized in Tables 2, 3 and 4. In Table 2, which gives the average yield for all locations and years, there appears to be little if any increase for foliar application, but the sidedress application increased the yield about 100 pounds of seed cotton per acre. (Table 2) When the results are tabulated in this

Table 1.—Rate and frequency of nitrogen applications

	Lbs. N/A Preplant[1]	Lbs. N/A Sidedress	Lbs. N/A Spray	% N in Solution	No. of applications	Lbs. N/A per applications
1958	24	30	30	3%	6	5
1959	18	24	24	3%	5	4.8
	18	24	24	5%	3	8
1960	12	36	36	3%	6	6
	12	36	36	6%	3	12

[1]Preplant nitrogen applied to all treatments including the check. These plots received either side dress or spray but not both.

Table 2.—Effect of nitrogen application on yields at 5 locations for 3 years.

Treatment	Pounds seed cotton/A
Check	1471
Foliar: Urea-ammonium nitrate solution (3% N)	1423
Foliar: Urea solution (3% N)	1497
Foliar: Urea solution (5%N)[1]	1462[2]
Sidedress: Ammonium nitrate (33.5% N)	1534

[1]Applied as 6% N in 1960.
[2]Two-years only.

Table 3.—Effect of foliar applications of nitrogen on the yield of cotton at the Black Belt, Pontotoc Ridge, and North Mississippi Branch Stations.

	Yield, Pounds seed cotton per acre	
Treatments	1959-60	1958-60
Check	1330	1315
Foliar: Urea-ammonium nitrate solution (3% N)	1401	1384
Foliar: Urea solution (3% N)	1482	1467
Foliar: Urea solution (5% N)[1]	1417	
Sidedress: Ammonihm nitrate (33.5% N)	1518	1460

[1]Applied as 6% N in 1960.

Table 4.—Effect of foliar applications of nitrogen on the yield of cotton at the Brown Loam and Central Stations.

	Yield, Pounds seed cotton per acre	
Treatments	1959-60	1958-60*
Check	1673	1840
Foliar: Urea-ammonium nitrate solution (3% N)	1469	1651
Foliar: Urea solution (3% N)	1522	1687
Foliar: Urea solution (5% N)[1]	1534	
Sidedress: Ammonium nitrate (33.5% N)	1634	1772

*At Brown Loam Station Only
[1]Applied as 6% N in 1960

way, it might be concluded that foliar application of nitrogen to cotton is ineffective even though there is a need for additional nitrogen for optimum yield. However, when the results are summarized according to response, or lack of response to a sidedress application a different conclusion is drawn.

According to results in Table 3, for locations showing a response to nitrogen sidedressing, it is evident that foliar application increased the yield. The foliar applied urea solution containing 3% N was as effective as was the sidedressed ammonium nitrate, but the urea-ammoninum nitrate (3% N) and the more concentrated urea solutions (5-6% N) were not. The yield increase for these solutions was a little less than one-half as much as was obtained with sidedressed ammonium nitrate, or with the less concentrate urea solution (3% N). Failure of the urea-ammonium nitrate solution (3% N) to be as effective as the urea solution containing 3% N is attributed to leaf-injury (burning) from the ammonium nitrate while the failure of the urea solutions containing 5-6% may be attributed in part to leaf-injury and possibly to less frequent application as well. Although the urea solutions containing 5-6% N burned the leaves, the degree of burning was not as great as with the urea-ammonium nitrate solution. Even so, it is highly improbable that an urea solution containing 6% nitrogen would be as effective for foliar application as one containing 3% nitrogen when both the frequency and the rate of application of nitrogen per acre are the same. Solutions of urea containing 4% nitrogen are perhaps about as concentrated as should be employed for foliar application to cotton.

Results for locations where there was no increase in yield from a sidedress applications are shown in Table 4. From these results it is evident that foliar application as carried out in these tests actually reduced the yield where enough nitrogen was already available in the soil. The urea-ammonium nitrate solution caused the greatest reduction in yield, which again indicates that it injured the leaves more than did the other solutions. Also, it is apparent that foliar application of urea solutions as concentrated as those reported herein should be made to cotton, only where nitrogen deficiency is recognized and not as a general practice just to provide insurance against the development of nitrogen deficiency.

With Insecticides?

There has been some interest in the possibility of supplementing soil application of nitrogen with foliar application by adding urea to the insecticide and spraying both on at the same time. However, in terms of the frequency of application and the volume of insecticide per application, relatively small amounts of nitrogen would be applied in this way using the most concentrated solutions of urea that appear to be feasible.

For example, with ground equipment the volume of insecticide per acre per application during the fruiting season probably does not average more than 5 gallons, and if applied by airplane, the volume perhaps does not average 2 gallons per acre. Therefore, for a nitrogen concentration of 3% as urea, one gallon of insecticide would contain approximately one-third pound of nitrogen. Thus, with ground equipment, the average rate of nitrogen per application of insecticide would be about 1.7 pounds per acre, and with aerial application, about 0.6 pound per acre. Should foliar application of nitrogen with the insecticide be commenced upon recognition of nitrogen deficiency in late July—after which 8 applications of insecticide were made—then ground equipment would apply a total of 14 pounds of nitrogen per acre, and aerial equipment, about 5 pounds per acre.

This is not enough nitrogen to correct a noticeable deficiency. Thus, either the concentration of urea or volume of solution must be increased. If formulated with

enough water to give 16 to 20 gallons per acre, an insecticide solution containing 3% nitrogen would give a per-acre rate of nitrogen of 4 to 5 pounds per application, which would be sufficient to correct a recognizable nitrogen deficiency if 5 or more applications were made. However, because of the volume of solution involved, this would be entirely impractical with aerial equipment and possibly with ground equipment as well.

Even though a moderate nitrogen deficiency may be corrected by foliar application, it is probable that the need for such a practice will seldom arise where recommended practices for soil application are followed. Should a deficiency result because of excessive leaching from very sandy soils during rainy periods or because of gaseous loss of nitrogen by denitrification from clayey soils which have become water-logged, it is highly probable that the deficiency will occur early enough in the growing season for a soil application to correct it. In most cases, nitrogen deficiency in cotton in July can be corrected as effectively by soil as by foliar application even though it may be necessary to apply the nitrogen on the surface of the soil. For late-season surface applications, faster and more efficient utilization will be made if a source high in nitrate nitrogen is used.

Corrosion

Urea solutions are not corrosive to iron, steel, aluminum, fiber glass, and plastics, such as nylon; but galvanized metals, copper and brass may be corroded slightly. Therefore, if urea is to be sprayed with the insecticide, equipment should be made of materials that are not corroded by it. In most cases, this will amount to no more than substituting aluminum, stainless seel, or nylon nozzles for brass nozzles which are commonly used.

Ammonium nitrate solutions corrode iron and steel readily and copper, brass and galvanized metal are rapidly and severely corroded. Therefore, such solutions should not be applied with equipment commonly used for insecticides.

Fertilizer-grade urea is conditioned to improve its physical properties during storage and application by coating the prills with clay, or some other material which may be insoluble in water. For this reason, fertilizer grade urea is likely to be unsuitable for foliar application because the clay, or other conditioner would plug up the spray nozzles. Feed-grade urea would be satisfactory as it is not conditioned.

Biuret

In the production of urea, some biuret is formed. Fertilizer-grade urea usually contains from 1 to 2% biuret. It has been found that biuret in solution is very toxic to citrus fruit when sprayed on the foliage.

A test was conducted to determine the toxicity of biuret to cotton when sprayed on the foliage in varying concentrations. The application schedule is shown in Table 5. To provide a check, a biuret-free solution of urea (3% N) was spray-

Table 5.—Effect of foliar applications of biuret in urea on the yield of cotton.

Total-lbs./A		Lbs./A Per application		No. of applications		Lbs. seed
Biuret	N as Urea	Biuret	N as Urea	Biuret	N as Urea	cotton/A
0	0	0	0	0	0	1593
0	36	0	6	0	6	1483
0.6	36	0.1	6	6	6	1460
1.2	36	0.2	6	6	6	1503
2.4	36	0.4	6	6	6	1437
2.4	36	0.8	6	3	6	1497

Biuret applied in an urea solution containing 3% nitrogen.
18-54-54 base application.
Sidedress with 54 lbs. N/A.

ed on the foliage at weekly intervals at the rate of 6 pounds of nitrogen per acre per application. Foliar application was begun the first week of July and a total of 6 applications were made. Varying amounts of biuret were added to identical urea solutions and applied to the cotton at weekly intervals as was the urea solu tion on the check plot.

According to results shown in Table 5, foliar application of urea again reduced the yield but the yield was not reduced further by adding biuret to the urea solution. The highest rate of biuret, 2.4 pounds per acre, is equivalent to a per-acre rate of 160 pounds of urea containing 1.5% biuret. It is highly unlikely that a larger amount would ever be applied.

Therefore, it appears that the amount of biuret commonly found in fertilizer grade urea is not toxic to cotton when applied to the foliage with urea solutions containing 3 to 6% nitrogen.