Research with nitrogen fertilizer emphasizes..

FERTILIZE CROP—NOT CROP RESIDUE

B. A. KRANTZ • F. E. BROADBENT • W. A. WILLIAMS
K. G. BAGHOTT • K. H. INGEBRETSEN • M. E. STANLEY

SUMMARY

1. Results of field experiments indicate that it is more efficient and effective to apply nitrogen to the crop than to previous crop residues months ahead of planting the crop.

2. The increase in water infiltration rate resulting from various green manures or crop residues was inversely related to the nitrogen content at the time of incorporation. Low-nitrogen residues had a longer-lasting effect than legumes or other high-nitrogen residues.

3. The beneficial effect of barley crop residues on infiltration was significantly reduced by nitrogen application to the residue.

4. Addition of straw, along with fertilizer nitrogen, greatly reduced the uptake of fertilizer nitrogen by the succeeding crops.

5. The time required for cycling fertilizer nitrogen through the soil organic fraction and back into available form apparently involves a matter of years, or perhaps decades, rather than weeks or months.

6. Fine shredding and early incorporation of crop residues into a moist soil are key factors in handling residues to avoid interference with planting operations.

NITROGEN and other deficient nutrients should be applied at the time, placement, and rate most beneficial to the crop. Some agriculturists have recently promoted the idea of fertilizing residues to promote rapid decomposition and store up a "bank account of nitrogen in the soil." There is considerable difference of opinion on the efficiency, effectiveness, and wisdom of residue fertilization. In cold climates, as in northern United States, fall fertilization with ammonium nitrogen for spring crops is an ideal practice. However, the situation is far different in the irrigated lands of California where the winter soil temperature is above 45°F, and nitrification of ammonium fertilizer takes place at an appreciable rate in a moist soil. Winter rains expose these nitrates to loss by leaching in sandy soils or denitrification by temporary waterlogging in clay soils. This report summarizes field experiments and greenhouse tests in California on the nature of nitrogen transformations.

Sugar beets

An experiment was initiated in 1964 to compare the effectiveness of nitrogen applied to barley residues in the fall with nitrogen applied as a side-dressing to the succeeding sugar beet crop. Results (see table 1) indicate a marked response was obtained from nitrogen fertilizer side-dressed to the sugar beet crop. No increase in sugar yield was obtained from 30-, 60-, or 120-lb-per-acre applications of nitrogen applied to the barley residue the previous fall. It is likely that the fall-applied nitrogen was leached below the root zone by winter rains in this permeable Yolo loam soil. The yield reduction from fertilizing residues with 120 lbs N in the fall, compared with side-dressing 100 lbs N on the beets in the spring, was 3270 lbs per acre of sugar. At $4 per cwt, this meant a loss of $130.80 per acre.

Barley

In a large-scale field experiment in Tulelake, fall application of 84 lbs N per acre as ammonium sulfate was made just prior to plowing. This was compared with the same amount of ammonium sulfate applied at barley planting time the following spring. The yields from these two treatments were: (1) 84 lbs N applied on barley residues in the fall, 3346 lbs per acre; and (2) 84 lbs N applied at barley planting time in spring, 4209 lbs per acre (least significant difference .05, 431 lbs).

The yield reduction from fertilizing the residues in the fall, compared with fertilizing the barley in the spring, was 863 lbs per acre. At $2 per cwt, this means a loss of $17.26 per acre. This indicates that even under the relatively cool conditions which occur in the Tulelake area, much of the fall-applied ammonium nitrogen was either nitrified and lost or immobilized and unavailable to the succeeding barley crop.

In Monterey County, liquid ammonium nitrate was sprayed on barley stubble in late February just prior to plowing for "fallow" and compared with dry ammonium nitrate broadcast in late October just prior to seeding barley. The experiment was conducted under rainfed (dryland) conditions with nitrogen applied at the rate of 40 lbs per acre. Control plots receiving no nitrogen averaged 2199 lbs per acre. The fall application of nitrogen gave a significant yield increase of 350 lbs per acre. The late-February application on the stubble gave only a 212-lb increase which was not significant. Again, fertilizing the residue tended to be less efficient than fertilizing the crop at planting time.

TABLE 1. SUGAR YIELDS AS INFLUENCED BY FALL NITROGEN APPLICATION ON BARLEY RESIDUE VS DIRECT NITROGEN APPLICATION TO SUCCEEDING SUGAR BEET CROP ON A YOLO LOAM SOIL AT UC, DAVIS

Nitrogen applied to residues	Pounds per acre of N applied as side-dressing on beets				
	0	50	100	150	200
Lbs/A	Sugar yield in cwt per acre				
0	55.7	74.9	90.6	91.9	93.7
30	53.7	72.9	87.6	89.9	89.8
60	56.5	69.9	86.2	92.3	93.2
120	57.9	79.2	90.5	87.7	90.2

LSD (.05) between nitrogen side-dressing, means = 8.6 cwt.

Amount of barley crop residue: 5860 lbs per acre containing 0.25% N.
Nitrogen source: ammonium nitrate.
Fall nitrogen application to barley crop residues: November 24, 1964.
Nitrogen side-dressing to succeeding sugar beet crop: June 9, 1965.

Safflower

In the Sacramento Valley much of the safflower is grown on heavy rice soils, and, for convenience, some growers have applied nitrogen in the late fall. To evaluate the effectiveness of fall vs spring application, trials were established on Sacramento clay soil in Colusa County in 1960 and 1961. The results (table 2) indicate that spring applications were significantly better than fall applications for both years. On the average, the spring application yielded 478 lbs more safflower than the fall application. At $4 per cwt, this means a loss of $19.12 per acre from fall application. In 1960 aqua ammonia was injected at 6-inch depths, and in 1961 urea was broadcast and disked in. The rainfall between time of fall application and spring application was 9.4 inches in 1960 and 5.8 inches in 1961. The exact reason for the reduced effectiveness of the fall application is not known. It is probable that much of the ammoniacal nitrogen applied in December was nitrified, and subsequently denitrified during periods of temporary waterlogging in the winter season.

TABLE 2. FALL VS SPRING NITROGEN APPLICATION—COLUSA COUNTY 1960 AND 1961

Nitrogen rate	Date applied	Yield		Average of 1960 & 1961	
		1960	1961	Yield	Increase due to N
Lbs/A		Pounds per acre			
0		1312	1447	1380	
100	December	2064	2060	2062	682
100	March	2453	2627	2540	1160
L.S.D. (.05)		242	249		

The results from these five experiments indicate that applying nitrogen to the crop is far more efficient and effective than applying nitrogen to previous crop residues months ahead of planting the crop.

Water infiltration

One of the important reasons for incorporating residues in soils in irrigated agriculture is the possible beneficial effect upon water infiltration. This is particularly true in fine textured soils where water intake is slow. In a series of studies involving the application of nitrogen on residues, it was found that the beneficial effect of residues on infiltration was reduced by nitrogen application to the residues. It is believed that this is due to the more rapid decomposition of the residues with nitrogen application.

In one of these trials, barley crop residue was incorporated and irrigated both with and without 120 lbs N per acre on August 23. Furrow infiltration measurements from mid-September through mid-July showed consistent decrease in infiltration during this period. The mean infiltration rate in the residue plot was 1.57 inches per hour. In the residue-plus-120 lbs-N plot, the rate was only 1.31 inches per hour, which was a significant reduction. All residue treatments were significantly better than the fallow plot.

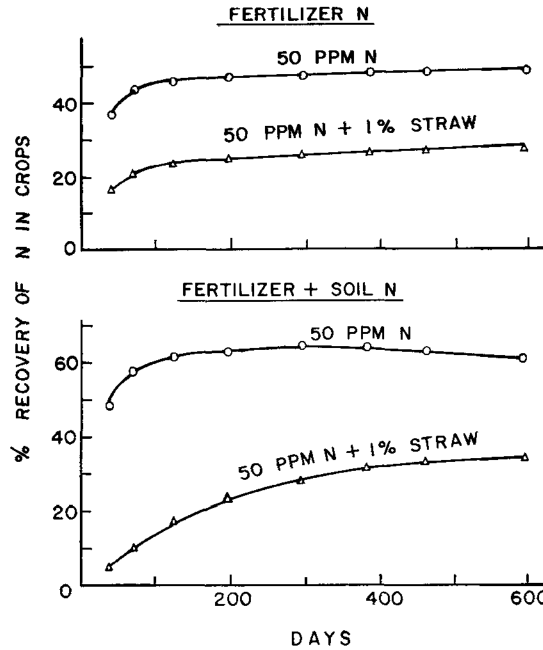
Earlier studies also showed that high-nitrogen materials such as legumes and mustard green manure were less effective than low-nitrogen residues such as corn stover, barley straw, and grasses. In fact there was an inverse relationship between the nitrogen content of the residue and the effectiveness of the residue in improving infiltration in the succeeding crop.

These data appear to be at variance with the time-honored data of past decades which showed that high-nitrogen organic matter from legumes was much more beneficial than low-nitrogen residues from grass-type plants. However, in these cases the succeeding crops were not fertilized with sufficient chemical nitrogen and the main effect of the legumes was to contribute nitrogen to the succeeding crop. With the availability of low-cost chemical nitrogen and the know-how for application to the succeeding crop, attention is now being focused on making the most effective use of previous crop residues for the improvement of water infiltration and other physical properties. Once again, it appears that it is better to let the previous crop residue decompose slowly without fertilization—and then to provide adequate fertilization for the crop at the best time and using the most desirable method.

Nitrogen immobilization

When nitrogen fertilizers are applied to soil, a group of processes are set into motion which utilize inorganic nitrogen and compete with the crop for the fertilizer. Until recently it was difficult to study these processes since one could not distinguish added fertilizer nitrogen from soil nitrogen. However, a distinction can be made by labeling the nitrogen fertilizer with the isotope N^{15}. Since this isotope is stable, it can be used to study the fate of nitrogen fertilizers in long-term experiments.

Biological immobilization is one process which competes with the crop for added nitrogen fertilizers. Microorganisms in the soil require nitrogen for growth and reproduction just as do higher plants. If conditions favor rapid development of the soil micropopulation, a considerable quantity of fertilizer nitrogen may be incorporated into microbial



Uptake of fertilizer and soil N by eight cuttings of sudangrass on Montezuma clay.

cells. One such condition is the presence of readily decomposable crop residues. It is well known that with the incorporation of carbonaceous crop residues, nitrogen deficiency of the succeeding crop may result unless fertilizer is supplied for the crop.

It has been commonly assumed that nitrogen immobilized by the soil microorganisms is tied up only temporarily and that this will be released again within a matter of weeks or months as the microbial cells undergo decay. This assumption was tested in an experiment with Montezuma clay and Yolo fine sandy loam. Both soils received additions of tagged ammonium sulfate equivalent to 50 ppm N in the presence (and absence) of 1 per cent barley straw. The soils were then cropped to sudangrass in the greenhouse over a period of 596 days—during which time eight cuttings were harvested. The graph shows the cumulative plant uptake of fertilizer N and of fertilizer plus soil N in Montezuma clay. Most of the fertilizer nitrogen was taken up in the first crop with little change thereafter. There is no indication of rapid turnover of the fertilizer nitrogen immobilized in the presence of the straw. There was some increase in release of soil nitrogen in the presence of fertilizer, as shown in the bottom half of the graph, but the trend of the curves suggests that many years will be required before fertilizer recovery from the straw treatment finally equals that from the treatment without straw.

In a similar experiment with Columbia fine sandy loam, calcium nitrate was used as the fertilizer to avoid the complication of ammonium fixation. Nitrogen uptake by a succession of seven cuttings of sudangrass, grown over a period of nearly two years, is shown in table 3.

TABLE 3. PERCENTAGE OF UPTAKE OF FERTILIZER N BY SEVEN CUTTINGS OF SUDANGRASS

Crop	Percentage of added fertilizer N	
	No residue	2% straw
1	52.4	10.9
2	6.7	5.2
3	1.4	2.5
4	0.6	1.4
5	0.4	1.4
6	0.2	0.7
7	0.1	0.9
Total	61.8	23.0
Roots	12.8	4.9
Remaining in soil	22.8	72.0
Lost	2.6	0.1

Where straw residue was applied, nearly three-fourths of the fertilizer nitrogen remained in the soil at the end of the experiment. Even without the addition of straw more than one-fifth of the fertilizer nitrogen remained in the soil. It is also interesting to note that the bulk of the nitrogen in either case was absorbed by the first crop. The second crop absorbed only 5 to 6 per cent, and very little nitrogen was released thereafter. These results suggest that nitrogen immobilized in the decomposition of carbonaceous crop residues becomes progressively less available as time goes on and may not be mineralized for many years.

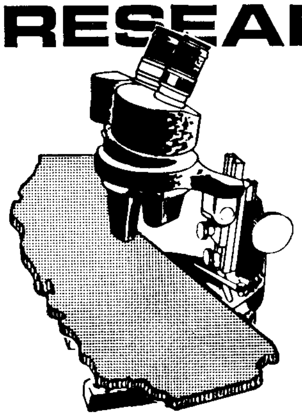
Handling crop residues

One of the main problems with crop residues is the possible interference with tillage, fertilizer injections, or planting. One of the best ways to avoid these problems is to use stalk shredders and early incorporation of the residue to start the decomposition process. If this is done immediately after a timely harvest, there is usually sufficient soil moisture to start decomposition. Under normal practices, these partially decomposed, finely chopped residues will not interfere seriously with the planting operation. The fine shredding and early incorporation may also be helpful in certain insect and disease problems. If the succeeding crop is to be planted shortly after residue incorporation, nitrogen should be applied in a preplant treatment or in a starter fertilizer to provide ample nutrients for the crop, particularly during the seedling stage.

Where very large amounts of residues are present, or certain insect problems exist, it may be desirable to apply nitrogen to promote more rapid decomposition, but such an application should not be regarded as contributing materially to the nitrogen requirements of the crop.

B. A. Krantz is Extension Soils Specialist; F. E. Broadbent is Professor of Soil Microbiology, Department of Soils and Plant Nutrition; W. A. Williams is Professor of Agronomy; and K. H. Ingebretsen is Extension Technologist, University of California, Davis. K. G. Baghott and M. E. Stanley are Farm Advisors, Modoc-Siskiyou Counties and Monterey County, respectively.

RESEARCH PREVIEWS



A continuing program of research in many aspects of agriculture is carried on at University campuses, field stations, leased areas, and many temporary plots loaned by cooperating landowners throughout the state. Listed below are some of the projects currently under way, but on which no formal progress reports can yet be made.

GROCERIES ON CREDIT?

Agricultural economists at Davis are studying the possibility of retail grocers (including the big food chains) adopting a credit card system as a form of non-price competition in the sale of foodstuffs. Of major importance is the impact such a system would have on food retailing.

•

PESTICIDES IN FORESTS

The use of pesticides to control forest insects may be having unintentional side effects. Just how the insecticides may be changing the normal life patterns of birds, desirable insects, and foliage is the subject of a study by specialists of the University, State Department of Fish and Game, and the U. S. Forest Service.

AERIAL POLLINATION

Agricultural engineers working out of Riverside are experimenting with aerial pollination of dates, using helicopters and ground level blowers with extended nozzles. Being tested are different frequencies and rates of application, with an evaluation of effect of temperatures during the pollinating season.

•

ORNAMENTAL IMPORTS

Specimen trees of the genus *Callitris* and some outstanding *Eucalyptus* varieties have been planted and are being studied by ornamental horticulturists at Davis, with a view to introducing variations in landscape plantings that could be adapted for a great many effects.

BLACK ROT IN SPROUTS

The bacterium *Xanthomonas campestris*, causing the black rot disease of crucifers, has been isolated for the first time from California brussels sprouts by plant pathologists at Davis. Black rot bacteria are seed-borne and as yet have been found in California only in association with foreign-produced seed lots. Seed-borne bacteria were found present in lots of variety Jade Cross and subsequently in the field-grown plantings. Control of the black rot disease is obtained by use of disease-free seed.

•

PIERCE'S VIRUS IN ALFALFA

The possibility of seed transmission of dwarf disease (Pierce's virus) has prevented export of California-grown alfalfa seed to a number of countries. Plant pathologists at Davis grew over 4,500 alfalfa plants using seed from heavily diseased plants. The experiment was made in an isolated area and no case of seed transmission of the disease could be found in subsequent plantings.

•

SPACING BEET FIELDS

Plant pathologists at Davis have determined the distance beyond which the viruses causing beet mosaic and beet yellows in sugar beet cannot be carried by normal means.