FERTILIZER NITROGEN RECOVERY IN IRRIGATED UPLAND COTTON

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Abstract

Field studies were carried out for the purpose of evaluating fertilizer nitrogen (N) recovery of upland cotton by use of the difference technique. The treatments under study included: i)check (no fertilizer N applied), ii)standard approach (preplant and side dress), iii)feedback approach (based upon soil and plant factors), and iv)2x feedback approach. The studies were carried out at two locations Maricopa (MAC) and Marana (MAR). MAC is a low elevation location with a coarser textured soil compared to the MAR location. 'DPL-20' was the variety used in both locations, except for the early years at MAC where 'DPL-90' was used. The sources of fertilizer N were urea and ammonium sulphate, which were side dress and split applied. In general, for the MAC location the final N fertilizer rates (NFR) applied were higher than for MAR due to higher yield potentials. The total N uptake increased as the NFR increased. The N use efficiency (NUE) values were reduced as NFR increased. The N fertilizer uptake (NFU) showed a decreasing pattern in the first years, and then an increasing trend; which was coupled with rather high amounts of N taken up in the check plot (soil N mineralized). When the N uptake in the check plot was high, NFU values were low, and vice versa. At MAC the N uptake in the check plot, due to mineralized soil N, revealed a slight increasing trend during the first years and then, after the fourth year, a rapid reduction of the N mineralized in the soil (check plot). A similar pattern was observed for MAR, although the amount of N taken up was smaller compared to the MAC location.

Introduction

In desert agricultural areas water and N are the two major agronomic inputs. It is important for farmers to use N fertilizer efficiently to maintain an optimum return in yield for the amount of N fertilizer provided. Also, from an environmental standpoint, it is important to manage N fertilizer so as to minimize nitrate (NO_3^-) leaching losses. The purpose of the present study is to evaluate the fertilizer N recovery associated with different N management tools using the difference technique. Fertilizer N recovery by a crop can be estimated by two different techniques: 1)the difference (or indirect) technique, and 2)the ^{15}N (or direct) technique. With the difference technique an apparent recovery fraction (ARF) is calculated from the amounts of N taken up by the crops in unfertilized (NP_o) and fertilized plots (NP), and the amount of N fertilizer applied (NF)(Alcoz, et. al., 1993; Harmsen and Moraghan, 1988; Rao et. al., 1991; Rao et. al., 1992; Roberts and Hanzen, 1990) according to equation 1:

(1) $ARF=(NP-NP_o)/NF$

The difference method generally provides higher fertilizer N recovery estimates than the ^{15}N technique (Carefoot et. al., 1993; Harmsen and Moraghan, 1988; Hauck and Bremner, 1976; Rao et. al., 1991). The basic assumption associated with the difference method is that immobilization-mineralization and other N transformations which are operative during the course of the experiment are the same for both fertilized and unfertilized plots. This assumption is often questioned because fertilized plots have shown to have greater N mineralization and root development than unfertilized plots (Harmsen and Moraghan, 1988; Westerman and Kurtz, 1974). Relatively low fertilizer N recoveries have been reported for cotton (*Gossypium hirsutum L.*), which has been increased by using nitrification inhibitors (Freney et. al., 1993). Field experiments were established from 1989 through 1995 at the University of Arizona Maricopa Agricultural Center (MAC) and Marana Agricultural Center (MAR) with the following objectives: 1) estimate the NUE of several rates of N fertilizer on upland cotton using the difference technique; 2) compare the NUE of upland cotton grown in two locations of Arizona; and 3) evaluate the use of N management tools to improve the overall efficiency for the grower.

Materials and Methods

The MAC location (353 m) has a Casa Grande sandy loam soil, whereas MAR is a higher elevation (600 m) location with a Pima clay loam soil. The four treatments utilized in this study included: 1) check (no fertilizer N added), 2) standard or aggressive approach (preplant and sidedress), 3) feedback approach (N fertilization based upon soil and plant factors), and 4) 2X feedback approach. The experimental design used was a randomized complete block with three replications at MAC and four replications at MAR. The information reported includes seven years of data from MAC and two years from the MAR location.

A variety utilized at both locations was DPL-20; DPL-90 was also used in the early years at MAC (1989-1992). The plots consisted in eight, 1 m wide rows, 240 m in length at both locations (full length of the irrigation run). The N sources were urea (used from 1989 to 1993) and ammonium sulphate (used during 1994 and 1995 at MAC); all the N applied was side-dress and splitted.

Results and Discussion

The total N fertilizer application rates ranged from 0 (check) to 373 $kg \cdot ha^{-1}$ for MAC and from 0 (check) to 253 $kg \cdot ha^{-1}$ for MAR. The total N uptake ($kg \cdot ha^{-1}$) for the entire seven

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year period tended to increase as the NFR was increased (Figure 1 and 2). The NUE response reveals an "optimal" value between 150 and 200 $kg \cdot ha^{-1}$ (Figure 3).

The N fertilizer uptake (NFU) or the amount of N fertilizer that is estimated to be taken up by the plant from the difference technique at MAC, shows in general, a decreasing pattern during the first four years (Figure 5). After the fourth year (1992), the NFU values increased. This pattern corresponds with the high values of N taken up by plants in the check plots (Figure 6), which is derived primarily from the N mineralized in the soil. For the MAC location the irrigation water supplied approximately 35 kg $N \cdot ha^{-1}$ per year, whereas at MAR the amount of N supplied was negligible. However, this result is biased by the high variation associated with the N uptake measured in the check plots. This is also shown in Figure 6, where the values of N uptake in the check plots at MAC and MAR locations are presented, revealing an increasing pattern during the early years and then decreasing. During the last year (1995) at MAC, the N taken up in the check plots was found to increase again, which was due to the fact that the entire experiment was moved to another location due to field rotational needs. This resulted in a resumptions of N uptake values in the check plots similar to those observed in the earlier years at this location.

At the MAR location (Figure 6) an increasing pattern of N uptake in the check plots is observed initially similar to the MAC location. Also, the total amount of N taken up by the plants at this location is lower.

Conclusions

The "optimum" NFU was observed for the treatment 3 (feedback approach) at MAC with a rate of approximately 150 kg $N \cdot ha^{-1}$. Also, with this treatment the best yields were obtained.

The NUE is reduced as the NFR is increased, and as this happens the yields are lowered. The NUE values are comparable to those reported for cotton and other crops in another areas (Alcoz et. al., 1993; Carefoot et. al., 1993; Freney et. al., 1993).

The NFU and the NUE values were higher for MAC than MAR. One possible reason could be that the N mineralization at MAR seems to be very high in the check plots.

The N uptake in the check plots (mineralized soil N) showed slight increases in the first years, and then declined. This indicates an apparent drawdown in the mineralizable pool of soil N, which is a very interesting aspect of this study. The soils at both locations have less than 0.5% organic matter and are classified as hyperthermic or thermic soils. Therefore, one would expect a rather and rather rapid (one to three years) and complete exhaustion of mineralizable soil N, which should be clearly expressed in the check plots of studies such as this one. Therefore, the capacity with which these soils were able to support growth, yield, and associated levels of N uptake demonstrates a greater N mineralization potential than one would normally tend to project. Accordingly, the questions associated with the size of the "early mineralized" soil N pool and the dynamics associated with the mineralization-immobilization transformations are most intriguing and worthy of further study.

A related project at these locations includes an evaluation of fertilizer N uptake and recovery using the ^{15}N technique, which should provide an interesting contrast to the data from the present study.

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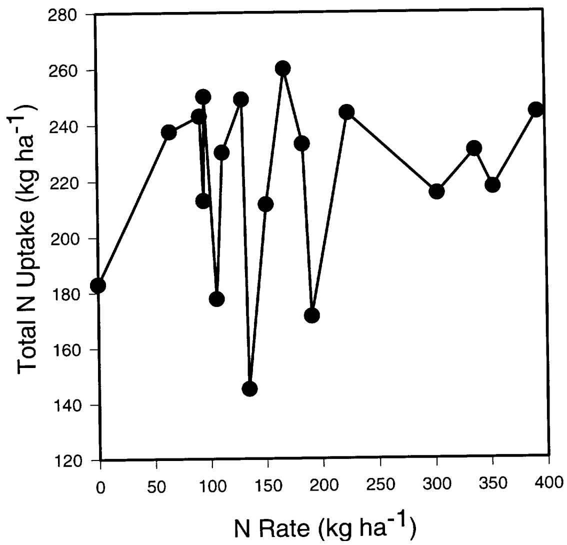

Figure 1. Total N Uptake as affected by N Rate, Maricopa, AZ, 1989-1995.

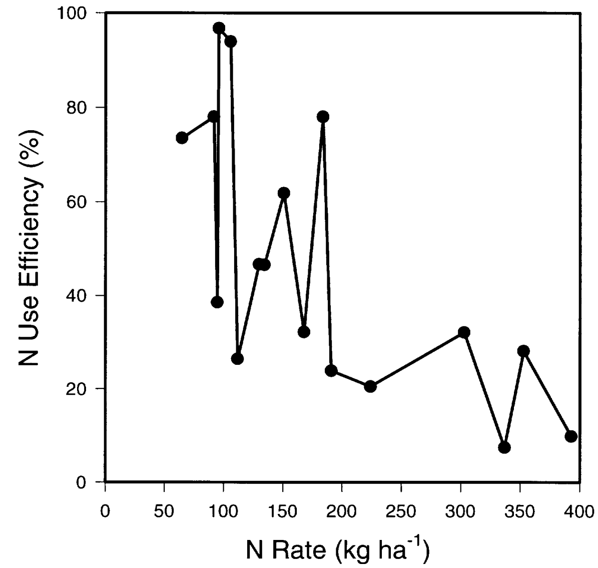

Figure 3. N Use Efficiency as affected by N rate, Maricopa, AZ, 1989-1995

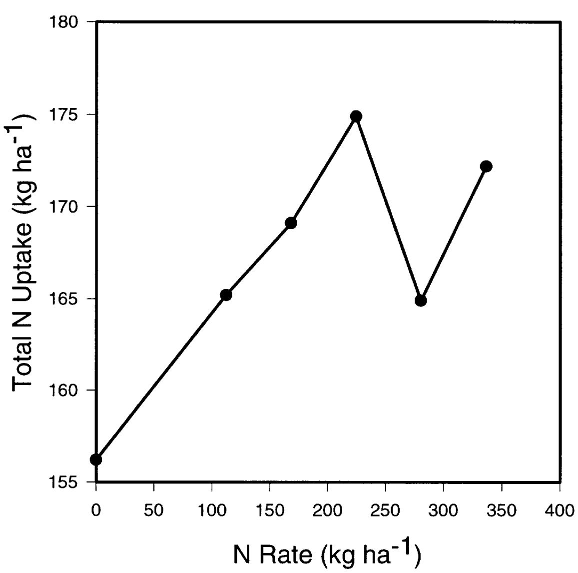

Figure 2. Total N Uptake as affected by N Rate, Marana, AZ, 1994-1995.

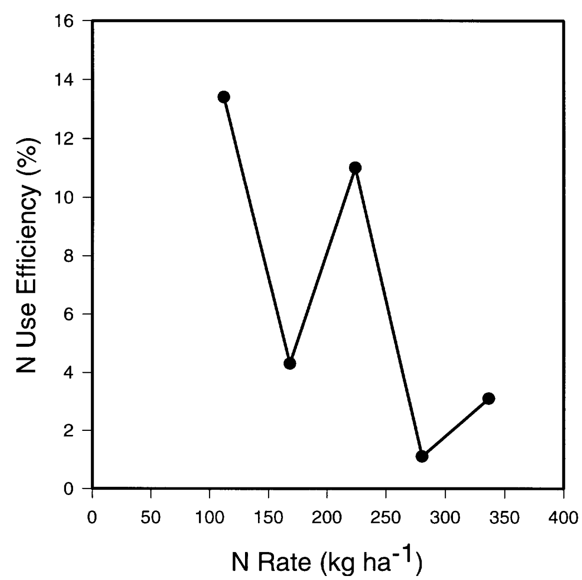

Figure 4. N Use Efficiency as affected by N Rate, Marana, AZ, 1994-1995.

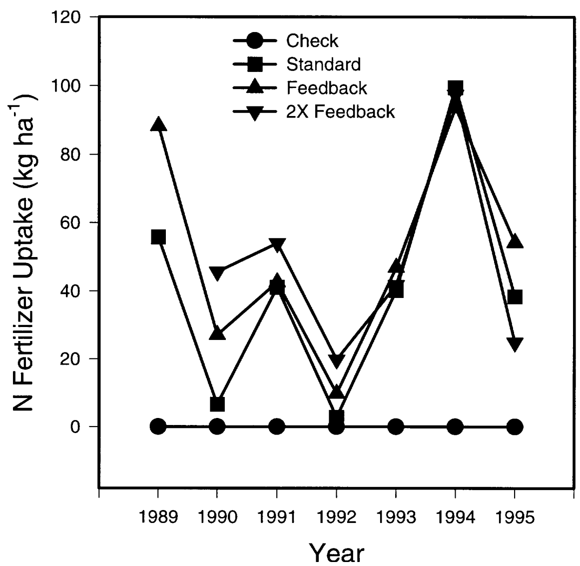

Figure 5. N Fertilizer Uptake, Maricopa, AZ, 1989-1995.

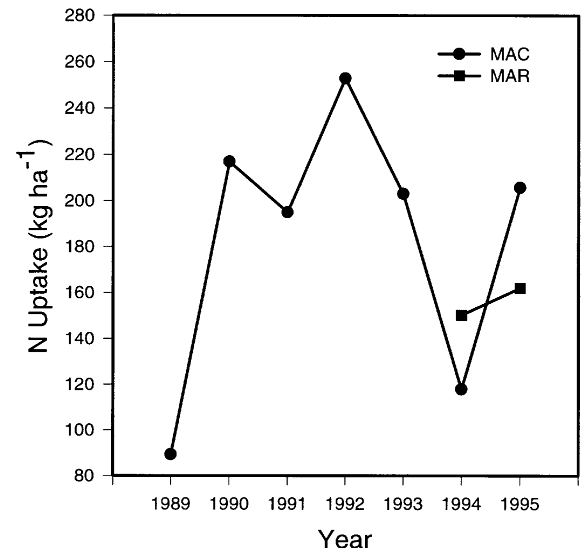

Figure 6. N Uptake for Check Plot, Maricopa and Marana, AZ, 1989-1995.