YIELD RESPONSE AND FERTILIZER NITROGEN RECOVERY BY DRYLAND SUNFLOWERS IN A NO-TILL ROTATION

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Abstract

Knowledge of sunflower response to fertilizer nitrogen (N) and fertilizer N recovery in the Central Great Plains region is limited. The objectives of this study are: (i) to measure N response under no-till managed summer fallow and (ii) to determine N fertilizer recovery of this crop in a wheat-millet-sunflower-fallow rotation as affected by placement. Urea fertilizer solutions labeled with 3 atom % ^{15}N were applied to 4 leaf stage sunflower in a wheat-millet or (corn)-sunflower-fallow rotation. In a two season study, 6 fertilizer placement methods were tested: surface broadcast, surface band(dribble), subsurface band; and three deep subsurface placements of: 60 cm (2 ft), 120 cm (4 ft) and 165 cm (5.5ft) deep. Labeled urea-N was applied at N rates of 30 and 60 lbs N/acre 4 inches away from the sunflower row in 4, (30 inch wide rows) row micro-plots 2 m long. At R-4 and at physiological maturity 3-4 Plants are harvested at the soil surface and separated into leaves, stems and heads. Each plant tissue was oven dried weighed and ground and analyzed for N isotope ratio. The highest fertilizer recovery was found in the subsurface banded treatment both years (60-70%). With the 60 cm placement we measured as much as 54% fertilizer recovery. The dribble treatment and the surface broadcast treatments were similar with average recoveries of 35 and 40% respectively. At the 120 and 165 cm depths we measured average recoveries of only 18 and 16% respectively.

Introduction

The current worldwide demand for edible oils has improved the profitability of sunflowers (*Helianthus annuus* L.) in the Central Great Plains. Since 1990, the region has had an increase in sunflower planted acres of over 650,000 (National Agricultural Statistical Service 1990, 1999). However, knowledge of sunflower response and fertilizer recovery of N and micronutrients in the region is limited.

In a study conducted in western Nebraska (Galeta et al., 1997) researchers measured a sunflower grain yield increase with added N in only one sunflower crop out of 40 tested (2.5%). In that study, researchers also reported a seed oil content decrease with added N and reported that phosphorous fertilization did not increase seed yields. Most other crops in the region do show grain yield responses to added N (Vigil et al., 1995, Halvorson and Reule 1994; and Westfall et al 1996, Vigil and Nielsen 1998). In that literature, optimum N fertilizer rates for those dryland crops are often between 30 and 80 lbs of added fertilizer N per acre. In North Dakota, Black and Bauer (1992) reported that most years 60 and 90 lbs of N/acre significantly increased sunflower seed yields in three different tillage systems. Black and Bauer (1992) also reported data indicating that in dry years the 90 lb N rate on average reduced sunflower seed yields. Lamond and Vigil (1999) report a general guideline for the N requirement of sunflowers is 50 lbs of N per 1000 lbs of potential grain yield. That value is based on research where the total N recovered by the above ground portion of the crop is compared to the grain produced. An analysis of Black and Bauer (1992) data indicates that the N requirement is about 60 lbs of N per 1000 lbs of grain yield. In North Dakota, the yearly evaporative demand is less than that measured in the Central Great Plains region and generally precipitation storage efficiencies are greater as one moves north. Less evaporative demand with a similar annual precipitation amount should result in

greater yield potential (Peterson et al. 1998). All of the above mentioned data suggest that somehow sunflower grown in the Central Great Plains region is able to scavenge enough N left over from previous fertilization to produce seed yields that match the yield potential of the region. The lack of significant sunflower seed yield response to fertilizer N has been reported by farmers and researchers in Kansas (Mikesell, 1994), Colorado (Vigil et al 2000) and Nebraska (Galeta et al 1997).

Labeled N (^{15}N) offers a unique method to investigate and trace the fate of fertilizer N in cropping systems (Hauk, 1973). In Nebraska experiments with corn (*Zea Mays* L.) Gass et al. (1970) measured N recovery with depth using ^{15}N labeled KNO_3. They measured 30% recovery by corn at the 60 cm depth and 60% recovery at a 9 cm depth. They also reported that less than 10% of the N recovered came from depths below 90 cm. Peterson et al. (1979) and Anderson et al (1972) used ^{15}N to measure the depth of NO_3^- extraction by sugar beets. They found that irrigated sugar beets could find and utilize N placed 240 cm deep in the profile. With irrigated corn in Colorado Benjamin et al. (1997) reported 47 to 62 % of the N added as fertilizer was recovered in an N placement experiment. In Nebraska, Vigil et al (1991) reported Fertilizer N recoveries of 55 to 62% for irrigated corn. No such data for dryland sunflowers exists in the literature. The objectives of this study is: (i) to measure N response under no-till managed summer fallow and (ii) to determine N fertilizer recovery of this crop in a wheat-millet-sunflower-fallow rotation as affected by placement.

Methods

In June of 1997, 1998 and 1999 sunflower was planted no-till into a dryland rotation established in 1994 at the USDA-ARS Central Great Plains Research Station (Akron, Colorado) on a Weld silt loam (fine, smectic, mesic, Aridic Argiustols), a Platner silt loam (fine, smectic, mesic, Aridic Argiustols) and a Rago silt loam (Pachic Argiustolls). The experimental design is a randomized split-plot 4-rep experiment. Two replications are planted in weld soil, one in Rago soil and one in Platner soil. Main plots (Individual plots are 60 ft by 240 ft in size) consist of rotation crop/phase (a wheat-proso millet(or corn)-sunflowers-fallow rotation). Sub-plots (60 by 60 ft in size) are fertilized at N rates of 0, 30, 60, or 90 lbN/acre.

All plots are managed using no-till technology where weeds are controlled using herbicides. Because of the rotation no weed control is needed in the wheat crop. However, after wheat harvest weeds are controlled with 12-16 ounces of roundup (glyphosate) the rate depending on the size of the weed population. If corn is to be planted the following spring 0.5 lb a.i. of atrazine is used in August with the roundup as a residual herbicide. For millet two burndown application of roundup are used to control weeds. One in mid May and one at planting (12 to 20 oz of roundup depending on weed size and population). Prior to planting sunflowers a split application of Spartan (sulfentrazone) mixed with roundup (if needed for established weeds) is sprayed half of the application goes on as early as possible (March or April) and the other half is applied two weeks prior to planting. The total rate of Spartan is 2.5 ounces /acre. Sunflowers are seeded at a seed drop rate of 16,600 seeds /acre on around June 10th of each year. In sunflowers following millet, Poast (sethoxydim) is used to control volunteer millet at a rate of 16 ounces per acre. When Sunflowers follow corn no additional grass control is generally needed. Soil water and inorganic N were monitored at planting and after harvest to assess water and N use efficiency and to evaluate deep N and water extraction by sunflowers.

In the check plots of the experiment 4 row micro-plots were used to investigate optimal fertilizer placement and fertilizer recovery. Because the rotation experiments check plots had been cropped now for three previous years with no fertilizer inorganic N levels in the upper 4 foot of the soil profile are less than 4 ppm at any soil depth. Six fertilizer placement methods were tested: surface broadcast, surface band(dribble), subsurface band; and three deep subsurface placements of: 60 cm (2 ft), 120 cm (4 ft) and 165 cm (5.5ft) deep. Labeled urea-N was applied at N rates of 30 and 60 lbs N/acre 4 inches away from the sunflower row in 4, (30 inch wide rows) row micro-plots 2 m long. At R-4 and at physiological maturity 3-4 Plants are

harvested at the soil surface and separated into leaves, stems and heads. Each plant tissue was oven dried weighed and ground and analyzed for N isotope ratio. Surface and deep placed ^{15}N labeled N is being used to evaluate fertilizer N recovery with soil depth and fertilizer recovery with N placement. Total biomass yield and N uptake are measured at petal drop and at near physiological maturity. Grain yield is measured at physiological maturity.

Results

With nearly 6 inches of rainfall in August, of 2000 we measured a significant yield response to added N fertilizer (table 1). This is the first sunflower yield response to fertilizer N we have measured at the station on these plots Figure 1. The four previous years, sunflower yields have ranged between 980 lbs and 1400 lbs regardless of fertilizer N amount. In other words, the check plots to which no fertilizer was added produced about the same amount of grain as the plots fertilized with 30, 60 or 90 lbs of N/acre in all years previous to 2000. Sunflowers respond vegetatively most years. That means a visual green up and an increase in plant size can be observed that increases with N rate, but that response usually does not result in more grain.

Table 1. Sunflower seed yield response in a wet year (2000) to fertilizer N, row spacing and micronutrients.

	Row spacing		
N rate	30 inch rows	20 inch no micronutrients	20 inch with micronutrients
lbs/acre	Grain yields (lbs/acre)		
0	1538 (39.2)*	1776 (39.9)	1963 (41.6)
30	2072 (38.0)	2417 (39.3)	2594 (40.4)
60	2090 (37.4)	2682 (37.2)	2556 (38.8)
90	2224 (36.9)	2505 (38.1)	2866 (38.6)

* Values in parenthesis are seed oil contents (%).

Table 2. Nitrogen fertilizer recovery in dryland sunflowers as measured by the isotope ratio technique.

	Fertilizer Recovery % ϕ		
Treatment	--1997--	--1999--	-- Average --
Band	63	69	66
Broad cast	34	51	43
Dribble	--	48	48
60 cm deep	44	60	52
120 cm deep	28	31	30
165 cm deep	17	25	21

ϕ values are averaged over all N rates and both sampling times each year.

From this research, we have determined that sunflowers need about 50 lbs of N/acre per 1000 lbs of potential grain yield. That N can come from residual N left over from previous cropping, or from mineralization of soil organic matter. The balance not met by residual N in the top two feet of the soil profile or mineralization of organic matter should be added as fertilizer. Yields were also significantly greater when sunflower was planted in 20 inch rows as compared to 30 inch rows (table 1). Micronutrients did not significantly increase or decrease sunflower yields, but significantly increased seed oil content in the year 2000.

In the micro-plot experiment using ^{15}N-labeled fertilizer, we measured a fertilizer recovery by dryland sunflowers that was 63% to 69% when the N was banded 4 inch deep, 4 inch away from the row (table 2). This means that if 100 lbs of N/acre were applied, 63 to 69 lbs of the 100 lbs applied would be recovered by the crop. The remaining 30-37 lbs would either be left over as residual N, immobilized by soil microbial biomass, or lost from the system through leaching, volatilization of ammonia or denitrified to N_2 gas. We were surprised to measure an average of 52% recovery from fertilizer N placed 2 feet deep. At the 4 foot placement we measured 28-31% recovery of fertilizer N. Only 17-21% recovery was measured at the 5 and ½ foot depth. Broadcast-applied N was used just for comparison. Only an average of 34% of the broadcast N was recovered in 1997. And so the broadcast-applied N was only about half as good of a placement method as the subsurface band placed 4 inches deep 4 inches away that year.

The implications of the deep placement study indicate that sunflowers are nearly as efficient at recovering N placed at a two foot depth as they are when fertilizer is placed, more reasonably, in a band 4 inch deep, 4 inches away from the row. One could interpret these results to indicate that, fertilizer N left over from a previous crop year, that hasn't left the top two foot of the soil profile might likely be recovered by sunflowers fairly efficiently. The results indicate an advantage in fertilizer recovery with subsurface banding as compared to surface broadcast applications.

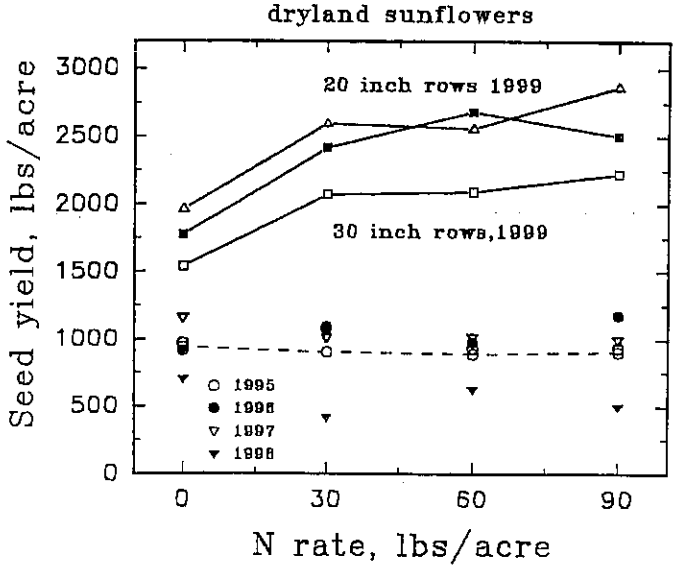

Figure 1. Sunflower seed yields over a 5 year period as affected by N rate at Akron, Colorado.

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