

Fertilizer Placement Affects Rate of Nutrient Uptake by Grain Sorghum in Conservation Tillage Systems

By Dan Sweeney

Public awareness of the environment, farm programs, and economic concerns have increased the amount of U.S. land planted in conservation tillage. With less soil mixing, placement of fertilizer becomes more important. Research has shown that fertilizer placement can affect yields in conservation tillage systems. Surface or subsurface banding often has resulted in greater nutrient use efficiency than broadcast applications. The objective of this study was to determine the effect of broadcast, surface band (dribble), and subsurface band (knife) placements of N-P-K suspensions on dry matter production and N, P and K uptake by grain sorghum in conservation tillage systems.

Procedure

The experiment was conducted for two years on a Parsons silt loam, a typical claypan soil of southeastern Kansas. The soil was low in available P and K with a relatively high organic matter content. Fertilizer treatments included combinations of placement methods and timing of N applications, in addition to a no-fertilizer control. Preplant fertilizer application methods were broadcast, dribble and knife. Dribble and knife spacings were 30 inches, and knife depth was 4 inches.

Nitrogen timings were all N applied preplant and split N (50 percent of N applied preplant and 50 percent applied at the nine-leaf stage as a dribbled sidedress). Preplant N plus all P and K were applied as a suspension. Later N applications used a urea-ammonium nitrate (UAN) solution. Total fertilization rate was 150-100-150 (lb/A of N-P₂O₅-K₂O).

Fertilizer treatments were applied in each of three conservation tillage systems: reduced tillage - disk and field cultivate; ridge tillage; and no

tillage. Aboveground parts of four whole plants were collected at random from each plot at the nine-leaf, boot and soft dough growth stages, then weighed, and analyzed for N, P and K. Values were corrected by plant stands to calculate dry matter production and nutrient uptake on a per-acre basis. Dry matter accumulation and nutrient uptake were regressed against days after planting (DAP) for each placement method using cubic functions that maximized R² values for every variable. The first derivatives of these cubic functions then were taken to obtain uptake rates. The day of maximum uptake was determined by solving the equation obtained by setting the second derivative equal to zero.

Data were analyzed across years with

Knife (subsurface band) placement increased uptake of nitrogen (N), phosphorus (P) and potassium (K) by grain sorghum early in the season. Knife placement of N-P-K suspensions may also improve yield potential.

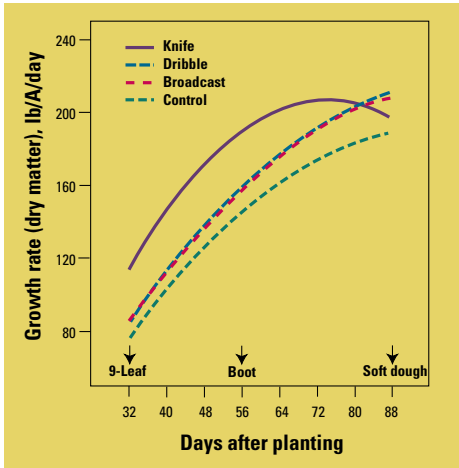


Figure 1. Rate of dry matter accumulation for broadcast, dribble, and knife placement methods and the control as obtained from the first derivative of dry matter accumulation functions.

minimal year by treatment interactions. Because none of the few year by treatment interactions for any variable occurred at more than one growth stage sampling, analyses of data were pooled across years to emphasize effects that were significant through all samplings.

Results and Discussion

Although no-tillage resulted in nearly a 30 percent decrease in dry matter accumulation and N, P, and K uptake at the nine-leaf growth stage when compared with either reduced or ridge tillage, further reductions at later growth stages were generally not significant (data not shown). In addition, split N applications or the interactions between tillage, placement method, and split N application had minimal effects on any of the parameters measured at the three growth stages.

The highly significant and uniformly consistent response to fertilizer treatments was due to placement method and to fertilization in general. The dry matter accumulation from the nine-leaf to the soft dough

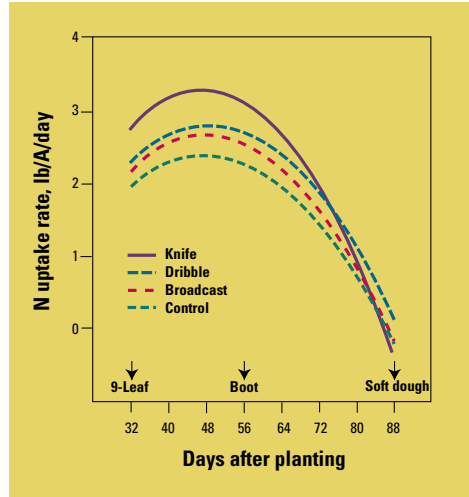


Figure 2. Rate of N uptake for broadcast, dribble, and knife placement methods and the control as obtained from the first derivative of N uptake functions.

stage of growth suggested that the plants grew slowly at first and then more rapidly to soft dough (data not shown). At the nine-leaf stage, knife placement of the N-P-K suspension resulted in greater dry matter production than either surface placement or the control. This difference became more pronounced during the season. The growth rates with surface placement methods did not appear to reach a maximum until after 88 DAP (**Figure 1**). However, knife placement appeared to result in maximum growth rate by 74 DAP.

Cumulative N, P and K uptake by grain sorghum followed a general sigmoid pattern with time (data not shown). The maximum rate of N uptake with knifing was approximately 1 lb/A/day more than uptake for the control and 0.5 lb/A/day more than uptake for the two surface placement methods (**Figure 2**). The maximum N uptake rate occurred near 49 DAP for all placement treatments. The maximum rate of P uptake with knifing was approximately 15 percent greater than that with either broadcast or dribble

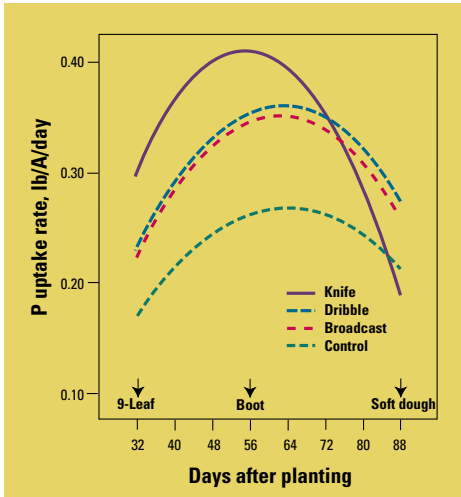


Figure 3. Rate of P uptake for broadcast, dribble, and knife placement methods and the control as obtained from the first derivative of P uptake functions.

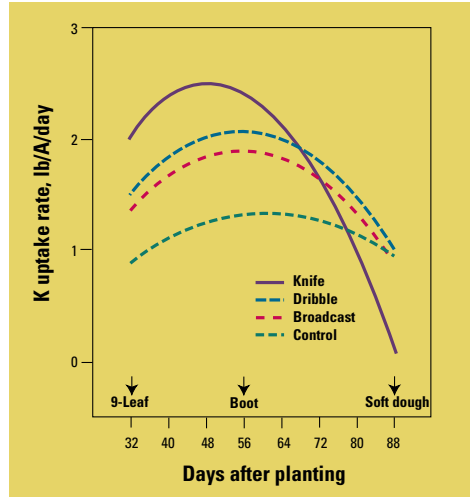


Figure 4. Rate of K uptake for broadcast, dribble, and knife placement methods and the control as obtained from the first derivative of K uptake functions.

placement methods and 50 percent greater than that for the control (**Figure 3**).

The maximum P uptake rate occurred at 56 DAP for knifing but approximately one week later for the control and the surface placement methods. This shift may be explained partially by differences in maturity.

Potassium uptake followed the same sigmoid patterns as N and P uptake (data not shown). Maximum K uptake rate with knife placement was nearly double the maximum rate for the unfertilized control (**Figure 4**). Even though uptake was less than with knifed placement, surface applications increased the maximum K uptake rate by 50 percent above that of the control. The date of maximum uptake with knifing was approximately 49 DAP, which was one week earlier than that for either surface placement method and two weeks earlier than that for the control. This effect of placement on the date of maximum K uptake cannot be explained entirely by a shift in maturity.

Summary

For each placement method and the control, the times of maximum rates of N, P and K uptake preceded the time of maximum rate for dry matter accumulation. The often-observed dilution of plant nutrient concentrations with time was demonstrated in this study by reduced nutrient uptake rates at later growth stages compared with the rate of dry matter accumulation. Knife placement increased the amounts and rates of N, P, and K uptake early in the season and appeared to shorten the time to reach maximum plant growth and P and K uptakes. The positional availability of knifed plant nutrients, especially P and K, early in the growing season may improve nutrient uptake by grain sorghum and also affect the kernel potential that is determined shortly after growing point differentiation and, consequently, yield. **BL**

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