# IS FALL DEEP BANDED FERTILIZER PLACEMENT SUPERIOR?

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## Introduction

Grain crop producers continue have interest in P and K fertilizer placement for several reasons. Issues include: (1) the need at high soil test, (2) alternatives to 2x2 because of planter attachment cost, (3) fertilizer use efficiency, (4) convenience/time limitations, and 5) potential yield benefits. Research has demonstrated that banded placement methods enhance the efficiency of nutrient use and can increase yield. This observation appears to be more important in high residue management systems where nutrient applications are not routinely incorporated. Research conducted by this author has demonstrated increased P and K uptake and yield where the planter 2x2 placement method is used compared with broadcast (Wolkowski, 2000; 2003). Response tended to be greater in no-till relative chisel because soil and environmental condition of the seedbed under no-till resulted in reduced early season plant growth and nutrient uptake.

Recent increases in cropping input costs have spurred interest in reduced tillage sys-tems that will not compromise productivity. True no-till (slot planting) has not been success-ful in Wisconsin because of our cool, wet spring soil conditions and therefore most producers have adopted some form of in-row residue management to modify soil conditions the seed zone. Strip-tillage popularity has increased because it overcomes some of the common problems associated with no-till planting such as imperfect planter slot closure, hair-pinning of residue, cool/wet seed zone conditions, and surface compaction. Strip-tillage buries slightly more residue than no-till, but still offers a better soil conservation alternative than most full-width tillage systems. Strip tillage, like many practices, has many variations of practice and hence some definitions are needed. Strip tillage for the purposes of this paper is considered to be tillage of an 8- to 10-inch wide area of the soil using attachments that move residue from this zone, run a mole knife 6 to 8 inches deep, and then form a berm of 2 to 4 inches in height. Typically the operation is done in the fall in fragile residue such as soybean or fall-killed alfalfa. Corn residue commonly plugs the strip tillage tool. The crop is planted over the center of the strip the following spring. Modern setups employ steering guidance systems to establish the strips and then facilitate planting on them the following year.

Several dealerships now offer a custom strip-tillage service that can be accompanied by the deep placement of fertilizer in the future row area. It has been suggested that fall application may eliminate the need for row fertilizer in the spring and avoid the delays and expense that are associated with spring fertilizer application with the planter. The suggestion has been made that deep placement may offset concerns with nutrient stratification in no-till. Several Midwestern research studies have compared the deep placement of fertilizer to other methods of application. Most of the focus of the research was on P and K. While N could be applied with deep banding equipment on strip tillage tools, its application in the fall would not be recommended in Wisconsin because of the relative inefficiency of fall N fertilization.

## Fertilizer Placement Methods

Methods of P and K fertilizer placement include: (1) broadcast — with or without incorporation, (2) banding — on the surface, with the seed, near the seed, or at some depth, (3) foliar — most appropriate with micronutrients. The selection of the method will depend on several factors including soil test level, crop, tillage management, equipment limitations, soil and residue condition,

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time constraints, and rate. Deep placement is considered by some to be a recent innovation; however it is clear from a review of the literature (Randall and Hoeft, 1988) that researchers have studied it for at least the last 50 years.

Randall and Hoeft (1988) describe the four broad objectives of a fertilizer placement decision to be: (1) the method promoting the most efficient nutrient use by the plant, (2) the prevention or reduction of nutrient loss resulting in environmental contamination, (3) avoidance of damage to the plant, and (4) the provision of an economical and convenient practice. Banding is generally accepted as the most efficient placement in terms of nutrient use, the safest method with respect to nutrient loss to the surface water, and of little risk to the plant as long as seed placement is not used. This leaves the fourth consideration – economics and convenience, which often trumps agronomics with respect to the final placement decision. They conclude that economic yield response of corn to P and K seldom occur at high or excessively high soil test levels and that at responsive soil test levels banding generally outperforms broadcast. It has been shown that crop rooting is enhanced in the banded zone and is likely responsible for the early growth observed with such treatment. Kaspar et al. (1991) demonstrated that banding in the row nearly double the root length of corn measured in the top 6 inches in the row compared to banding in the inter-row. Early season crop response to banded fertilizer does not always translate into an economic yield response, especially in years when adequate heat units are available.

The type of banding method selected is dependent upon its cost, equipment availability, cropping system, and soil conditions. Conceivably there could be an economic advantage to fall deep placement with a strip-till machine when factors related to equipment availability, planter attachment cost, time, and soil conditions are considered. The focus of this paper is to examine regional research that has compared fall deep banding in a strip-till system with broadcast or planter-placed methods.

## Research Comparisons

### Arlington, Wis.

A tillage/rotation study was established by the author in 1997 on a Plano silt loam soil at the Arlington Agricultural Research Station. The main plot treatment is rotation (continuous corn, soybean/corn, and corn/soybean). These treatments are subdivided into tillage subplot treatments (fall chisel/spring field cultivator, strip-till, and no-till). These treatments were maintained from 1997-2000 and the plots did not receive additional P and K fertilizer until the fall of 2000 when the current sub-subplot fertilizer placement treatments were installed. A rate of 200 lb/a of a 9-23-30 material was applied as a fall broadcast prior to primary tillage, in the row on a 2x2 placement at planting, and 6 to 8 inches deep in the strip-till treatment only. This rate of P and K approximates the UWEX recommendation for a 175 bu/a corn grain yield. An unfertilized treatment is also included. Tillage and fertilizer treatments were similar in corn and soybean each year. All treatments are replicated four times in a split-split plot treatment arrangement. Only the results of the strip till treatments for 2001 to 2004 will be discussed in this paper.

Strip-tillage was conducted in the fall with a tool that features finger coulters, a ripple coulter, a mole knife that runs 7 to 8 inches deep, all followed by closing disks that form a ridge about 3 inches high. Strips were alternated between rows each year and the succeeding crop was planted on the ridge the next spring in 30-inch rows. A Gandy air-delivery fertilizer system was mounted on the tool to meter the deep fertilizer placement. A full season corn hybrid (RM 105 days) or soybean variety (zone 2.1) was planted in early May. UWEX recommendations were followed for all non-treatment crop production inputs including pest management and supplemental N.

Table 1 shows the average soil test values (0 to 8 inches) for the strip-till treatments averaged over all crop rotations. The samples were collected after one fertilization event in 2001 and five fertilization events in 2005. These data show that drawdown from fertilization was similar to the increase observed where fertilizer was broadcast. Soil test P remained in the excessively high category after five seasons in all situations. Soil test K decreased slightly in the unfertilized treatment, but remained in the optimum category; however the soil test K in the broadcast treatment increased into the high category. Soil samples were not collected from either banded treatment (2x2 or deep placed).

Table 1. Average soil test values for the strip tillage plots in the Arlington rotation x tillage Study, 2001 and 2005, Arlington, Wis. †

| Year | pH | | Soil test P (ppm) | | Soil test K (ppm) | |
|---|---|---|---|---|---|---|
| | None | Broadcast | None | Broadcast | None | Broadcast |
| 2001 | 6.7 | 6.7 | 41 | 51 | 99 | 110 |
| 2005 | 6.7 | 6.6 | 38 | 56 | 91 | 120 |

† Values are the average of 0- to 2-inch incremental samples averaged over an 8-inch sample depth. Averaged over all crop rotations. Annual broadcast application: 200 lb 9-23-30/a.

One way to evaluate the responsive to P and K fertilizer placement methods is to measure the early season uptake by the crop. The uptake of P and K at about 45 days after planting (tallest corn at V6) is shown in Table 2. Uptake is the product of dry matter accumulation and plant tissue nutrient concentration. The uptake values shown in Table 2 are presented as mg nutrient (elemental basis) per plant. Rotation affected uptake in some years, possibly due to warmer soil conditions in the SbC treatment due to lower surface crop residue. The corn plants were often larger in this treatment. Fertilizer placement affected the nutrient uptake of both P and K in all years with the exception of P in 2002, which was significant at the p=0.10 level. Differences appeared to be the greatest where material was applied on a 2x2 placement with the planter compared to either broadcast or deep, although there were situations where there were no apparent differences in P and K uptake with respect to placement. This is likely due to the fact that fertilizer is placed the closest to the seed in the 2x2 method. Additionally, the broadcast and deep placement treatments are applied six months prior to planting, which could have resulted in more fixation of P and K by the soil. These results generally show that P and K uptake from deep placement was similar to that of broadcast, and does not demonstrate an advantage over planter placed material.

While it is apparent that deep placement was generally inferior in terms of early season nutrient utilization there still could be an advantage to this placement method as long as the applied nutrients were eventually utilized and yield was not affected. Table 3 presents the corn and soybean grain yields for 2001–2004. Rotation did not significantly affect corn yield in any year, but there was a strong trend each year for higher yield in first-year corn after soybean compared to continuous corn. Fertilizer placement did not affect corn yield in any year. Trends appeared to vary between continuous corn and first-year corn such that the 2x2 placement performed better in continuous corn, but not as well as the other placement methods in first-year corn. The relative responsiveness to fertilization appeared to be higher in first-year corn, compared to continuous corn. Soybean yield was more consistently affected by placement; however the effect varied between years and differences were relatively small. Overall these data do not demonstrate the superiority of any specific placement method with respect to grain yield over the 4 years of the study.

Table 2. Uptake of P and K by corn 45 days after planting as affected by fertilizer placement in strip-tillage, 2001 - 2004, Arlington, Wis.

| | | Year | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2001 | | 2002 | | 2003 | | 2004 | |
| Rotation | Placement | P | K | P | K | P | K | P | K |
| | | mg/plant | | | | | | | |
| CC | None | 21 | 102 | 6 | 32 | 15 | 80 | 14 | 102 |
| | Broadcast | 23 | 102 | 10 | 73 | 17 | 103 | 15 | 120 |
| | 2x2 | 27 | 188 | 10 | 81 | 17 | 124 | 18 | 155 |
| | Deep | 19 | 100 | 7 | 57 | 17 | 116 | 13 | 100 |
| SbC | None | 30 | 84 | 9 | 38 | 13 | 31 | 15 | 65 |
| | Broadcast | 27 | 123 | 12 | 84 | 20 | 83 | 17 | 122 |
| | 2x2 | 33 | 171 | 12 | 91 | 19 | 93 | 20 | 152 |
| | Deep | 26 | 127 | 12 | 94 | 17 | 75 | 17 | 101 |
| Pr>F | Rotation | <0.01 | 0.88 | 0.12 | 0.38 | 0.47 | 0.04 | 0.09 | 0.47 |
| | Placement | <0.01 | <0.01 | 0.08 | <0.01 | 0.01 | 0.05 | 0.03 | <0.01 |
| | R*P | 0.49 | 0.31 | 0.70 | 0.67 | 0.17 | 0.86 | 0.67 | 0.55 |

Table 3. Corn and soybean grain yield as affected by fertilizer placement in strip-tillage, 2001–2004, Arlington, Wis.

| | | Year | | | | |
|---|---|---|---|---|---|---|
| Rotation | Placement | 2001 | 2002 | 2003 | 2004 | Average |
| | | bu/a | | | | |
| CC | None | 181 | 172 | 148 | 173 | 169 |
| | Broadcast | 182 | 173 | 131 | 177 | 166 |
| | 2x2 | 182 | 179 | 137 | 183 | 170 |
| | Deep | 179 | 169 | 139 | 165 | 163 |
| SbC | None | 199 | 192 | 161 | 184 | 184 |
| | Broadcast | 210 | 218 | 200 | 203 | 208 |
| | 2x2 | 204 | 206 | 194 | 196 | 200 |
| | Deep | 207 | 217 | 199 | 186 | 202 |
| Pr>F | Rotation | 0.07 | 0.11 | 0.18 | 0.11 | |
| | Placement | 0.79 | 0.17 | 0.40 | 0.24 | |
| | R*P | 0.79 | 0.19 | 0.02 | 0.81 | |
| CSb | None | 57 | 50 | 34 | 55 | 49 |
| | Broadcast | 60 | 50 | 34 | 55 | 50 |
| | 2x2 | --† | 52 | 30 | 54 | 45 |
| | Deep | 61 | 53 | 31 | 50 | 49 |
| Pr>F | Placement | 0.09 | 0.76 | 0.09 | 0.05 | |

† The 2x2 placement was not included for soybean in 2001.

Iowa

Antonio Mallarino and his students conducted extensive studies of fertilizer placement for no-till for corn following soybean in both small plot and on-farm trials over a three year period (Mallarino et al., 1999). They examined response to P and K separately by applying non-limiting rates of one of these nutrients with two rates of the nutrient in question. They found that the planter-placed fertilizer increased early-season plant weight more than the other placements (data not shown). Early season growth responses to P were more common than to K. A summary of the yield effects of fertilizer placement for this work is shown in Table 4. The studies conducted in small plots at regional research centers did not show differences with respect to the placement of P, however the deep placed K significantly increased yield over the broadcast and planter placed treatments by 4 bu/a. Similarly the on-farm comparisons did not show a response to P, but deep K placement increased yield by 4 bu/a compared to broadcast. Planter-placed treatments were not evaluated in the non-farm studies. They conclude that the early season growth response seen with P did not guarantee a yield response, and likewise the lack of an early season response as seen with K did not preclude a significant yield response. Their data also show that a small part of the response to deep placement may be the result of the knife itself, independent of fertilization; however the difference is relatively small.

Table 4. Response of first-year corn following soybean to fertilizer placement in Iowa, (adapted from Mallarino et al., 1999).

| | | Placement | | | | . |
|---|---|---|---|---|---|---|
| Nutrient | Control | Deep w/o | Broadcast | Deep | 2x2 | Pr>F |
| | | ---------- | ---------- | bu/a | ---------- | |
| Small plots | | | | | | |
| P | 137 | 139 | 143 | 145 | 144 | 0.76 |
| K | 145 | 142 | 146 | 150 | 146 | 0.01 |
| On-farm | | | | | | |
| P | 136 | 138 | 144 | 142 | N/A | 0.24 |
| K | 136 | 138 | 142 | 146 | N/A | 0.02 |

Ontario

Vyn and Janovicek (2001) examined the response of corn following wheat at two locations in southeast Ontario, Canada. Growing conditions in that region are similar to those in Wisconsin. The soils had medium to high soil test K. Their study compared K rates in fall moldboard plow, fall strip-tillage, and no-till on soils having medium to high soil test K. Fall K was broadcast and incorporated in the plow, placed six in. deep in strip-tillage, and fall surface broadcast in the no-till. Plots were further split to include with and without treatment with spring planter-placed starter K (2x2). A summary of the corn grain yield for the Kirkton location is shown in Table 5. These data show that in all tillage treatments corn yield was increased by fall K when row fertilizer was not applied. If row fertilizer was applied an increase was only observed in moldboard. Deep K placement in strip-till increased yield in the absence of row K from 149 to 154 bu/a; however starter alone (no fall K) produced 157 bu/a. It can be argued that strip-till at modest rates of K (45 lb $K_2O$/a) produced yields nearly as large as those with planter-placed fertilizer alone when soil test K levels are responsive.

Table 5. Response of corn to K fertilizer placement at Kirkton, Ontario, three-year average. (adapted from Vyn and Janovicek, 2001).

| | Tillage and row K rate (lb $K_2O$/a) | | | | | |
|---|---|---|---|---|---|---|
| | No-till | | Strip-till | | Moldboard plow | |
| Fall K rate | Low | High | Low | High | Low | High |
| lb $K_2O$/a | ---------- bu/a ---------- | | | | | |
| 0 | 148 | 161 ** | 149 | 157 ** | 158 | 162 |
| 45 | 157 | 160 | 151 | 158 ** | 161 | 164 |
| 90 | 155 | 161 ** | 154 | 155 | 164 | 170 ** |
| Deep sig. | ** | NS | + | NS | * | ** |

Row K in the Low treatment was 10 lb $K_2O$/a in year one and 0 lb $K_2O$/a in years two and three.
+, *, ** = significant at the 0.10, 0.05 and 0.01 level, respectively.
Deep significance compares response to deep placement within a tillage and row K rate.
Row significance shown between low and high row K within tillage treatments.

## Minnesota

Researchers in Minnesota examined the response of corn to deep placement of K fertilizer in long-term ridge-till at three locations (Rehm and Lamb, 2004). Soil tests at all sites were greater than 140 ppm K (1 M ammonium acetate), and were categorized as high or excessively high with respect to K availability. Their evaluation did not show a relationship between yield and K rate for corn or soybean at any of the locations (Table 6). Potassium fertilization did increase the K concentration in corn earleaf at one of the three locations, but did not affect the K concentration in soybean leaves at the R1 growth stage. They concluded that deep placement of K is not a universal requirement for crop production in ridge-till, especially at high soil test levels.

Table 6. Response of corn and soybean to deep K fertilizer placement in long-term ridge-till at three Minnesota locations, (adapted from Rehm and Lamb, 2004).

| | K rate (lb $K_2O$)/a | | | | | . |
|---|---|---|---|---|---|---|
| Crop | 0 | 20 | 40 | 60 | 80 | Pr>F |
| | ---------- bu/a ---------- | | | | | |
| Corn | | | | | | |
| Blue Earth | 152 | 161 | 162 | 158 | 165 | NS |
| Dodge | 182 | 174 | 183 | 188 | 180 | NS |
| Pope | 168 | 168 | 169 | 173 | 162 | NS |
| Soybean | | | | | | |
| Blue Earth | 38 | 36 | 36 | 39 | 32 | NS |
| Dodge | 53 | 53 | 54 | 52 | 52 | NS |
| Pope | 42 | 40 | 42 | 42 | 41 | NS |

## Summary

Is fall deep banded fertilizer superior – the answer is no with respect to crop yield response. However there may be circumstances where this placement method for P and K may be favorable over broadcast and row-placement. Fall deep placement of N is not recommended because of the proven inefficiency of this practice. Advantages will be based on economics related to application cost and the time management considerations of the grower. Like any placement method response is most probable at optimum or lower soil test P and K levels and is likely coupled with growing season degree day accumulation. Deep banding does not appear to provide the same early season response that is observed with the traditional 2x2 placement, but will increase the uptake of P and K relative to the control. It can be assumed that corn eventually utilizes these nutrients and yield will be relatively unaffected by fertilizer placement. The use of deep placement in strip-tillage systems is a viable method of applying P and K at rates equivalent to or less than crop removal. At low and very low soil test levels some of the P and K should be broadcast to uniformly increase soil test. Deep placement has not been evaluated in full width tillage systems such as chisel or moldboard plowing and its benefit in those systems is unknown. Growers need to consider planter attachment costs and practicality when choosing a placement system for P and K. Recognize that soil sampling fields that have received deep banded fertilization may result in variable soil test levels if an inadequate number of cores and samples are collected.

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