Fertilizer Placement Boosts Crop Yields and Nutrient Recovery

By Robert Mikkelsen

The principles of 4R Nutrient Stewardship involve using the right nutrient source, at the right rate, at the right time, and in the right place.

Fertilizer placement is one of the essential components of crop production, but it does not always receive the attention it deserves.

A recent publication by Nkebiwe et al. (2016) reviewed 1,022 datasets from around the world within a process called a "meta-analysis" to get a broad view of potential advantages of subsurface fertilizer placement compared with fertilizer applied to the soil surface. This brief summary only touches on a few of the key points highlighted in their full paper.

There has been considerable research done on optimal fertilizer placement to boost nutrient recovery and crop yields, and to make them more competitive against weeds. However, studies have shown conflicting results, making it challenging to understand general trends. Terminology can be confusing because "fertilizer placement" refers to a variety of techniques used to place nutrients to a small area on the surface or in the subsurface soil. In addition to crop growth, fertilizer placement decisions will also influence environmental parameters such as nitrate leaching, gaseous loss of nitrous oxide and ammonia, and P runoff.

Decisions related to fertilizer placement need to consider many factors related to crop nutrient demand and potential losses. As examples, split applications of fertilizer may better match crop demands for key growth periods, but require greater labor and energy costs. Placement of fertilizer in the seed zone may be advisable for some crops, but high rates of fertilizer applied near seeds may damage the young plants. Surface application of N fertilizers must be done carefully to avoid elevated losses of ammonia. Starter fertilizer (applied 5 cm (2 in.) sideways and 5 cm. below the seed) helps sustain nutrient availability during early crop growth. Subsurface-applied fertilizer may be placed relatively shallow 5 to 10 cm or deep (>10 cm) depending on the objective. When fertilizer is applied relatively deep in the soil, it may be more available for plant uptake during periods of drought when the surface soil has dried.

Abbreviations and notes: N = nitrogen; P = phosphorus.

Crop Yield

The authors reviewed 722 datasets from 39 studies. On average, the result of subsurface fertilizer placement was a yield increase of 4%, compared with broadcast application. This yield increase ranged from 9% for potato, sugar beet, and winter wheat, 4% for maize, and no yield increase for soybeans and grass from subsurface fertilizer placement.

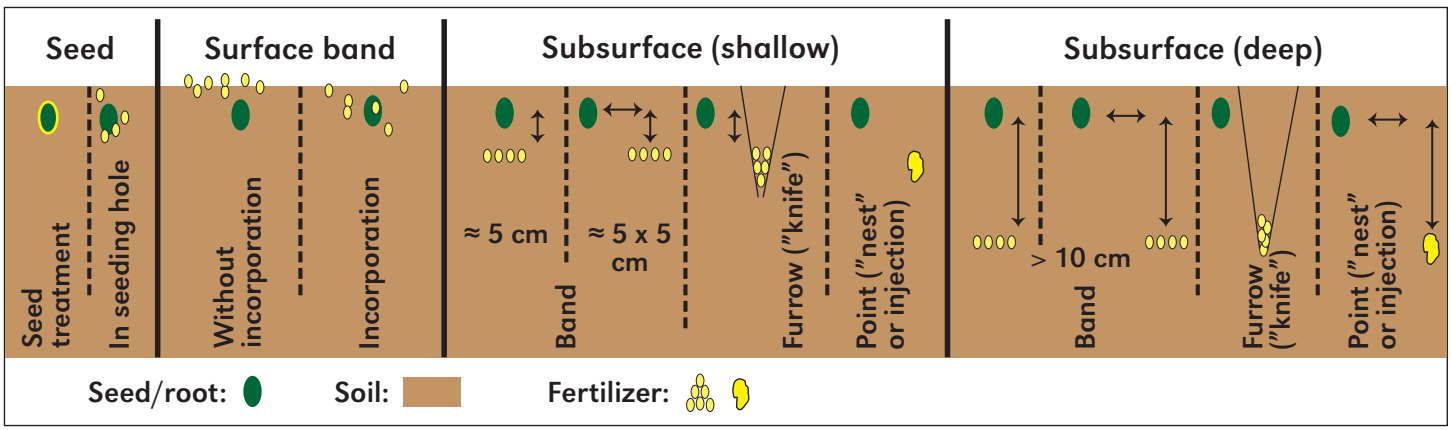
Of the 11 placement techniques analyzed, subsurface deep point injection resulted in the highest yield boost (6%) compared with surface application. The fertilizer materials most effective at increasing crop yield with subsurface placement (compared with surface application) was urea combined with soluble P (27% improved yield), ammonium with soluble P (15% improvement), urea (11% improvement), and ammonium (4%). These results are a good reminder of the yield benefits that often occur from combining urea or ammonium with soluble P fertilizer.

Plant Nutrient Concentration

When data from all crops and plant parts were combined (357 datasets), fertilizer placement techniques increased nutrient concentrations by 4%. This ranged from a 7% increase in nutrient concentration for maize when fertilizer is placed below the soil surface, to a slight decline in nutrient concentration in winter wheat, compared with surface application.

Plant Nutrient Content

Plant nutrient content refers to the quantity of nutrient accumulated in the above-ground portion of the plant. A synthesis of 235 datasets shows that overall nutrient content increased 12% when fertilizer was placed below the surface, compared with a surface application. Removing two outlier



Fertilizer placement techniques. Adapted from Nkebiwe et al., 2016.

studies boosted this to 19% increased nutrient uptake when fertilizer is strategically placed in the soil.

The trend for specific placement techniques was subsurface shallow band (15% increased nutrient content), followed by subsurface deep band (14%). Placement of ammonium (or urea) together with soluble P resulted in a consistent increase in nutrient uptake compared with either N or P alone.

Subsurface placement of fertilizers can result in increased yields, more nutrient uptake, and a higher nutrient concentration in plant tissues compared with broadcast application. This is likely due to:

1. The occurrence of high nutrient concentrations in close proximity to plant roots
2. Favorable chemical and biological changes in the rhizosphere
3. Stimulation of root growth in the vicinity of ammonium and soluble phosphate
4. Reduced nutrient loss to the environment
5. Deep placement (>10 cm) may provide nutrient access during times of drought stress

Subsurface placement of fertilizer can be a useful tool to improve farm productivity, but it must be considered for each field, crop, and nutrient. Additionally, subsurface fertilizer placement techniques require additional labor and energy, compared with surface application. The growing trend towards greater farm size can make it challenging to fertilize large fields in a timely manner when a slower application technique is used. However, the multiple advantages of this technique should be carefully considered as a part of the 4R Nutrient Stewardship strategy.

Acknowledgment

This article is a summary of the full article published by Peteh Mehdi Nkebiwe, Markus Weinmann, Asher Bar-Tal, and Torsten Müller. 2016. Fertilizer placement to improve crop nutrient acquisition and yield: A review and meta-analysis. Field Crops Research 196:389-401. BC

Dr. Mikkelsen is IPNI Vice President, Communications and a Director of the North American Program; E-mail: rmikkelsen@ipni.net.

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