by Drs. B. Eghball and D.H. Sander

Does Variable Distribution Affect Liquid P-Use Efficiency?

Florida scientist offers tips on how to use starters, plus describes the many benefits that accrue from their use. He focuses on corn.

Summary: *Experiments show that banding of liquid P is more effective than broadcast. The effectiveness of banded P has been shown to be increasingly superior compared to broadcasting P when P rate increases to the optimum level. The greater the speed of application, the smaller becomes the distance between droplets. Results of this study suggest that lower analysis P fertilizers could be more effective than widely used 10-34-0 for preplant banding and starter row applied fertilizers. Mixing of 10-34-0 with UAN may improve P-use efficiency both through improved P distribution and through ammonium-N effects on P uptake and P fixation.*

Banding either dry or liquid P fertilizer has been shown to be more effective than broadcast. Experiments with different rates of P indicate that handing becomes increasingly superior to broadcasting as P rate increases up to the optimum rate. In Nebraska, results indicate that seed applied P versus broadcasting becomes increasingly effective as the rate of application increases. Additional winter wheat trials showed that although both knife and seed application were superior to broadcast P, knifed P tended to be less effective than seed application at low P rates, but were equal at higher rates of application.

In a Kansas wheat trial, knifed P in a band spacing of 15 inches over four P application rates resulted in greater grain yield than seed applied P in a 7-inch spacing. Speculation attributes the difference to P distribution in the applied band. Distribution of P in the knifed or seed band could influence the probability of root-P fertilizer contact and affect soil-fertilizer contact.

Experiments have also shown that particle size of solid P, which affects the distribution of applied P in an applied band, is a factor that influences efficiency of P. Optimum P fertilizer particle size is affected by the relative severity of soil P fixation, plant root characteristics, band spacing, and proximity of seed row to the band.

Objectives of this experiment were to 1) determine how application variables affect the distribution of liquid P in a band, and 2) observe how different methods of P application relate to performance in the field.

Field observations

P distribution. Figures 1 through 5 are derived from multiple regression. Multiple regression indicates that liquid P distribution, as delivered from a standard hose pump, was significantly affected by rate of application, band spacing, and speed of travel (speed of pump revolutions) during application. Delivery tube size appeared to be less important in P distribution than other factors, but did interact with the rate of application.

Band spacing. Figure 1 shows that at a 12-inch band spacing (traveling speed of 2.8 mph with a tube size of 0.4 inch) P was delivered in unevenly spaced droplets. Droplet distances ranged from about 2 inches at a P_2O_5 rate of 15 lbs/A to zero distance or a continuous band at 75 lbs/A of P_2O_5. The amount of P in each droplet decreased (droplets became smaller) in direct proportion to the rate of P application (Figure 2).

Increasing band spacing decreased the distance between droplets at the same application rate (Figure 3). The smaller the band spacing, the greater the distance between droplets. With a spacing of 12 inches, distance between droplets was 2, 0.75, 0.35, and 0.12 inches with P_2O_5 application rates of 15, 30, 45, and 60 lbs/A, respectively. Continuous bands were formed at band spacings of about 17, 22, and 31 inches with application rates of 60, 45, and 30 lbs/A of P_2O_5, respectively. No continuous band of P was formed at 15 lbs/A of P_2O_5, even at the highest band spacing.

Effect of speed. Distance between droplets was affected by speed (Figure 4). As speed increased and pump speed increased, the distance between droplets decreased up to a speed of about 2.8 mph, where speed no longer seemed to affect droplet distances. Although delivery tube size did not significantly affect the distance between droplets, an interaction between rate and tube size indicated that tube size was affecting the solution distribution at low (<20 lbs/A

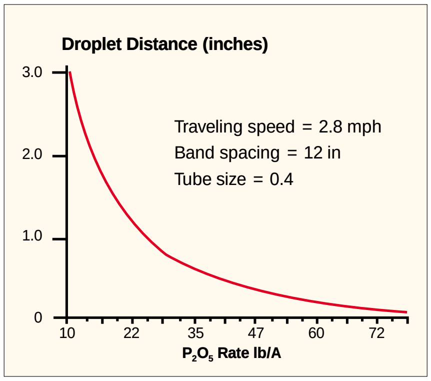

Figure 1. Effect of P application rate on distance between droplets in an applied band as determined from multiple regression.

of P_2O_5 in 12-inch band spacing) but not at high P rates (Figure 5).

Governing factors

It is apparent that liquid P distribution as commonly delivered from hose pumps is affected by several factors.

Application rate at each delivery point, which changes in direct relation to band spacing, is a primary factor. For example, continuous bands occurred only at P application rates of 78 lbs/A of P_2O_5 with band spacing of <12 inches. This indicates that row crop starter applications using 10-34-0 must be in excess of 30 lbs/A of P_2O_5 if they are to be applied in a continuous band, unless row spacing is wider than 30 inches.

Placement. Nebraska experiments on

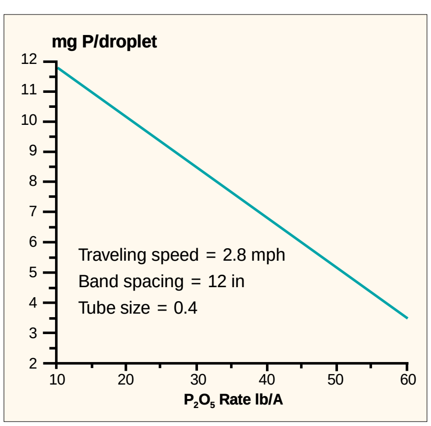

Figure 2. Amount of calculated P in each droplet as affected by P application rate using multiple regression

wheat and corn show the effect of different methods of P application on wheat grain yields as related to application rates (Figure 6). Both knifed bands and seed application had a spacing of 12 inches. Seed placement and knife methods of P application generally produced equal yields. However, a significant P rate by method interaction indicated knife applications became increasingly as effective as seed application and more effective than broadcasting as rate of application increased. Since knifed bands were applied prior to seeding, they varied in distance from the seed row, reducing the

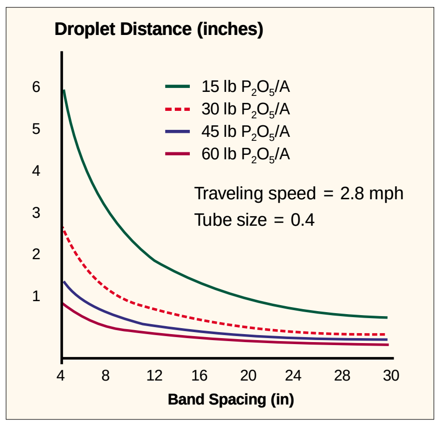

Figure 3. Effect of band spacing on distance between droplets at different rates of P application as determined by multiple regression

probability of root-P fertilizer contact, compared with seed applications. Therefore, one would expect seed application to be somewhat more effective than knifing at low P rates (as shown in Figure 6).

The disadvantage of knifing at low P rates seems to be overcome at high rates where a continuous band is applied. Figure 7 shows that knifed liquid P for irrigated corn was more effective at high P rates than at low rates. The predicted distance between droplets for the knifed P was 1.0 and 0.3 inch for the 18 and 36 lbs/A rate of P_2O_5, respectively. Closer distances between droplets at high rates increased the probability of root contact

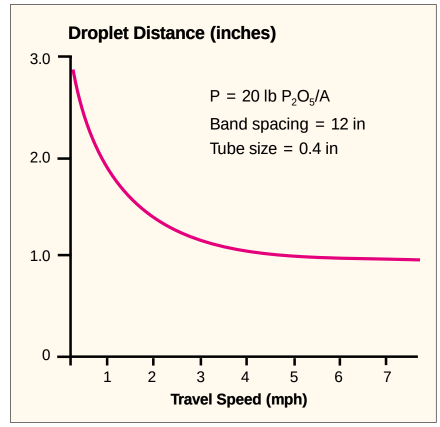

Figure 4. Effect of traveling speed on the distance between droplets in the applied P band as determined by multiple regression

with P, which is important in P uptake.

Figure 8 shows results of two methods of P application on grain yield on winter wheat in Kansas. In this experiment, the same amount of solution was applied for all P rates (the fertilizer solution was diluted for rates <50 lbs/A of P_2O_5). Knifed P resulted in higher grain yield than seed applied. The predicted distances between droplets were 0 (continuous band) and 0.7 inch for knifed and seed applied P respectively (rates determined from regression equation used in this study).

Root contact. The probability of root-P contact is known to be very important to P efficiency. The growth rate of roots is much greater in P-treated than untreated soil. It has been shown that

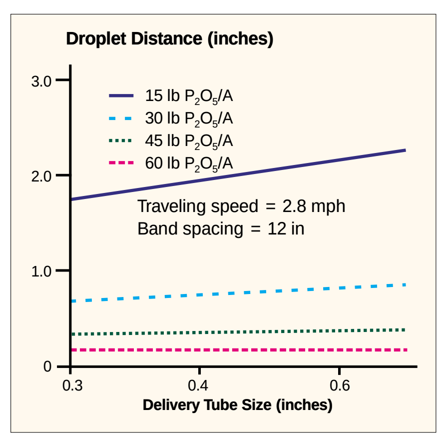

Figure 5. Effect of delivery tube size on distance between fertilizer droplets at different P rates as determined by multiple regression

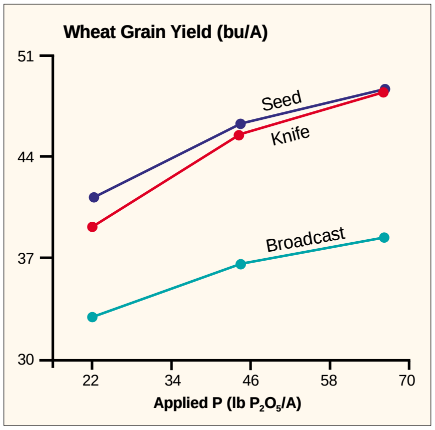

Figure 6. Effect of method of P application on wheat grain yield, Sander, et al.

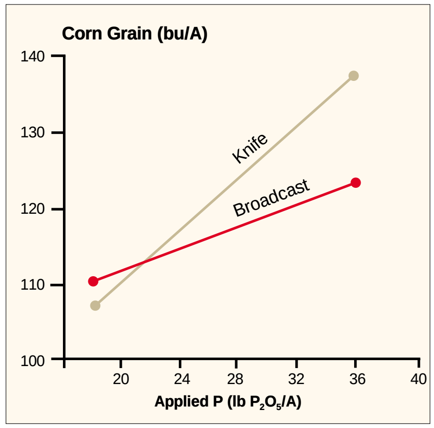

Figure 7. Effect of method of P application on corn grain yield, Raun, et al.

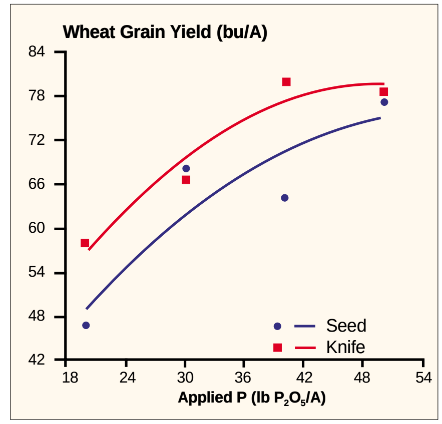

Figure 8. Effect of method of P application on wheat grain yield, Leikam, et al.

very sizable quantities of P can be absorbed by only a portion of the root system. It has been suggested that total P needs of a plant can be met via a single root. It appears that when roots contact a P droplet, root proliferation can be expected, as well as an increase in root growth in that part of the soil. However, exhaustion of P in that soil area affected by the P droplet or dry particle could be a limiting factor. Therefore root-droplet contact would have to be made with several droplets to ensure adequate P supply to the plants.

Calculations indicate that over 80 root-droplet contacts are needed for each corn plant at a yield level of 150 bu/A to ensure an adequate supply of P. This assumes an application rate of 30 lbs/A of P_2O_5 in a 15-inch band spacing (which provides a 0.5 inch distance between droplets with 17 milligrams P_2O_5 per droplet), a plant population of 25,000 plants/A, and a total P uptake of 80 lbs/A of P_2O_5 with 10 percent use of the applied P).

In contrast, we suggest that plant roots may follow a continuous band with only one root contact. However, with discontinuous bands, where fertilizer is placed in droplets or as dry particles too far apart to interact with each other, a new root contact may be needed for each droplet or particle. If true, since it is generally known that roots contact only 1 to 2 percent of soil volume, it appears reasonable that individual non-interacting droplets or particles would have a much lower probability of being exploited by the plant root than continuous P bands.

The benefit of adding UAN to starter fertilizers to produce about 1:1 $N:P_2O_5$ ratios (place at least 2 inches from seed for greater than 20 lbs/A of N on a sandy soil, and same distance for greater than 40 lbs/A on a non-sandy soil) may be due in part to the improved distribution of P reported in these studies from higher rates of P application. This does not diminish the importance of additional ammonium N in P uptake or the possible effects of high ammonium N concentra-tions on P fixation reactions, which may in turn keep more P in an available form. Better distribution, continued ammonium N presence, and possible delay of P fixation reactions are added factors in improved P response and the benefits of band placement of fluid P fertilizers.

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