ously with maize, whereas bush bean production is highest when beans are planted prior to maize. However, maize yields were significantly lower in the latter association. Temperature, location and cropping system may influence optimum bean production and must be investigated further.

Bean and maize yields were not affected by associated planting in single, double or the same row provided adequate planting density, a variety with yield potential and proper levels of fertilizer and pest control are utilized. In one trial, P589 and maize yielded 2000 and 4000 kg/ha, respectively, in four different playting systems. P589 yielded 4300 kg/ha when grown in monoculture.

Twenty varieties of bush and twenty of climbing beans are being critically tested in the two cropping systems during three growing seasons to study the correlation between yield in monoculture and in association with maize. If this correlation is consistent and the systems are appropriate to those used by the farmers, then the CIAT breeding program will continue to evaluate progeny and advanced lines in the more convenient monoculture system.

All CIAT accessions of climbing beans and tall semi-guide plant types are being evaluated by these two systems. More than 1500 lines have been evaluated, and the most stable, highest yielding entries from replicated yield trials are being tested at 5 locations. These materials will be entered in an international testing trial in 1977 at locations with different soil, temperature and moisture conditions.

More detailed summaries of specific trials are available from the authors in CIAT.

*****

1976 MINIMUM TILLAGE FIELD TESTS WITH SNAP BEANS

F. D. Tompkins and C. A. Mullins
The University of Tennessee

Field plots were established at The University of Tennessee Plateau Experiment Station to evaluate the effects of seedbed preparation and irrigation on stand establishment, plant characteristics throughout the growing season, yield, and pod quality. Snap beans of the Early Gallatin variety were seeded July 1 in Hartsells fine sandy loam soil. The plot site had been in orchardgrass sod for several years.

Five seedbed preparation and/or planting methods were employed. The control plots were turned with a moldboard plow and disked to prepare a conventional seedbed. The seedbed for one treatment was prepared by two trips with a powered harrow which pulverized the top 5 inches of soil and incorporated the surface residues. The only tillage for another treatment was two diskings which loosened the vegetation and roughened the soil surface. No-tillage procedures were used for the remaining two treatments. A fluted coulter furrow opener operating about 4 inches deep prepared the seed zone in one instance. Seedbed preparation in the remaining treatment was accomplished with an experimental vibratory furrow opener which tilled a narrow zone of soil to a depth of about 5 inches. The soil cutting tool oscillated at 25 Hz with an amplitude of 0.24 inches.

All treatments were seeded with the same commercially-available plate-type planter. Row spacing was 38 inches.

Granular fertilizer (8-12-6) was broadcast pre-plant at a rate of 800 lb/ac. Paraquat was applied at a rate of one qt/ac after the orchardgrass was clipped. Dinoseb (2qt/ac) and Amiben (2qt/ac) were applied immediately following planting. Manzate and Sevin were used as needed for pest control.

Irrigation water was not applied during the early portion of the growing season since ample moisture was available. One inch of water was applied to appropriate plots by sprinkler on two occasions: 40 days after planting and 55 days after planting.

Adequate plant stands were obtained with all treatments; established population generally averaged from 85,000 to 105,000 plants per acre. Poorest stands were obtained where the only tillage was surface disking. The vibratory opener established the greatest number of plants and averaged 13 percent more plants per row than the fluted coulter, the other no-till opener.

No-till plants exhibited more vigor during the early part of the season. Thirty-five days after planting no-till plants averaged over 5 inches taller than plants from the remaining treatments. However, by harvest, plants in all treatments were uniform in height. Irrigation did not produce taller plants, but irrigated plots produced an average of 0.63 ton/ac more plant material, exclusive of pods, than the non-irrigated plots. No-till plots produced 68 percent more plant material than the conventional plots.

Weed control was generally inadequate. Weed problems were greatest where the upper soil layer was stirred during seedbed preparation (disking or powered harrowing). Where the soil was left undisturbed (no-till) or the soil was inverted (moldboard plowing), weed infestation was less pronounced.

Pod yields were greatest where no-till practices were employed. No-till yields averaged 4.1 ton/ac, while the conventionally-prepared plots yielded only 1.9 ton/ac. The no-till yields were 58 percent above the yield averages for all other treatments collectively. Irrigation increased yields about 16 percent.

The no-till pods were much more mature at harvest than pods from the remaining treatments. Approximately 36 percent of the no-till pods were size 5 or larger as compared to an average of 17 percent for the other three treatments. Similarly, 8.6 percent of the pod weight was associated with the seed in the no-till beans while only 6 percent of the pod weight was attributed to the seed for the remaining treatments. Pod and seed size were affected very little by irrigation.

Pod moisture averaged 90.6 percent (wet basis) at harvest. The moisture content of irrigated pods averaged 1.5 percent higher than the content of non-irrigated pods.

*****

PHOSPHORUS FORMS AND AVAILABILITY FOR BEANS

R. Howeler
Center for International Tropical Agriculture
Cali, Colombia

The bean soil program has concentrated on the phosphorus nutrition of beans as this appears to be the element most limiting in major parts of Latin America. Beans have a very high requirement for P and if this element is not present in sufficient quantities, plant growth becomes stunted and yields reduced, without necessarily producing clear deficiency symptoms. In soils that are low in P the crop has to be fertilized with some P source to obtain maximum yield. The most common method is through P application to the soil, although foliar application has been tried with limited success. The most common P sources for soil application are triple superphosphate (TSP), simple superphosphates (SSP), basic slag, and a range of rock phosphates of various degrees of availability depending on the crystalline structure of the rock which varies among mining sites. Since most rock phosphates have their P in forms that are less easily available to the plant than that of TSP, the ground rock is sometimes pretreated with heat or acid or mixed with acidifying agents such as elemental S to increase its P availability. Although these sources generally are less effective than TSP because of a lower P availability, their relatively low price may make them economically attractive, especially since their high Ca content contributes to the Ca nutrition of the crop.

In 1975 and 1976 several trials were established in the acid, high P-fixing volcanic ash soils of Popayán to determine the relative effect of several sources on bean yield (Fig. 1). Nearly all sources gave a positive response to levels up to 400 kg P_2O_5/ha. These high application rates are necessary because of the low P content of these soils and their high P fixing capacity. The best source was basic slag, followed by TSP and partially acidulated rock phosphate. Least effective, but still contributing significantly, was the untreated rock from Huila. The superiority of basic slag over TSP on this trial is due to the method of placement, both being broadcast and incorporated like the other sources. This is the best placement method for all except the TSP, which is more effective when band placed. Due to its high agronomic effectiveness, low price, and high (60%) $CaCO_3$ content, the basic slag is the most economical P source for these soils. The acidulation treatment of the rock phosphate was also quite effective.

Figure 2 shows the response to application of various rock phosphates of different parts of the world. Again there was a positive response up to the level of 400 kg P_2O_5/ha. Though TSP produced highest yields, some of the more soluble rock phosphates such as those from North Carolina, Gafsa (Africa), Sechura (Peru), and Huila (Colombia) produced nearly equally