

Strip Intercropping

Intercropping is the practice of producing multiple crops in a given space. Throughout time and around the world, intercrops have been used to better match crop demands to available sunlight, water, nutrients, and labor. The advantage of intercropping over sole cropping (growing a single crop in a field) is that competition for resources between species is less than exists within the same species.

Intercropping has a long history, and is employed in many regions. In tropical agriculture, for example, tall and short crops are grown together to maximize production. In arid regions, intercropping improves the conservation of water. The “three sisters” of corn, beans, and squash grown by native Americans offer another example of intercropping.

Strip intercropping is the adaptation of this system to contemporary, mechanized agricultural practices. The multiple crops are grown in narrow, adjacent strips, that allow interaction between the different species, but also allow management with modern equipment.

For many years, crop rotations have been recommended because of the temporal diversity they provide in plant species and their resource requirements. Strip intercropping adds a spatial diversity to species across the landscape. It also distributes the labor requirements of that landscape more evenly through the growing season, and allows complimentary interactions that can boost yields and profits.

How does strip intercropping fit into Iowa's farmland?

Approximately 78 percent of the 27 million harvested acres in Iowa are devoted to corn and soybean production. Nearly one-

third of the corn produced is continuously cropped. Projections indicate that these two crops will continue to dominate the Iowa landscape. Strip intercropping systems have been designed with these two crops in mind. However, strip intercropping encourages the inclusion of third and/or fourth crop (Figure 1). In general, net gains in crop yield and economic return are the main short-term indicators of success or failure of a cropping system. As with any other business, farm managers will ultimately choose practices that maximize yield and economic return. Strip intercropping of corn and soybeans also meets this goal when optimized for individual farm needs.

Corn and soybean yield respond to a strip intercropping system

The response of these two crops to strip intercropping is most determined by the width of the strips in which they are grown (Figure 2). The earlier-planted and taller corn intercepts more sunlight at the border or interface with soybeans, and thus produces greater yields. However, soybean yields are suppressed at this border, mainly due to shading, water competition, and nutrient depletion by the adjacent corn (Figure 3.2).

In strips wider than four rows, the positive windbreak effect of corn on soybeans offsets some of the negative effects of shading and nutrient competition. Therefore, as the strips' width increases, negative impacts on soybean yield will decrease, and only the soybean rows bordering the corn strip will suffer. At the same time, as the strip width increases, corn advantages decrease because the ratio of outside rows to inside rows decreases. When water is not limiting, strip intercropping of corn and soybeans (strip widths greater than six rows) results in higher total production and net returns than sole-cropped (monoculture) systems.



Fig. 1. Barley, soybean, and corn crops in a 15 foot strip intercropping system in Northeast Iowa.

The addition of small grain strips to strip intercropped corn and soybean

The negative effects of shading and competition between corn and soybean can be reduced by adding another crop to the system. Small grains, such as oats, can be seeded much earlier to use early spring resources. Oats are planted at least a month before corn and soybeans, and they are already reaching maturity when corn and soybeans begin competing for water, nutrients, and sunlight. The harvest of oats in early summer ends their competition with the adjacent crops (Figure 5). As a result, both corn and soybeans produce greater yields directly adjacent to oats (Figures 3.1 and 3.3) than in strip middles. The oats also benefit from the lack of competition in early spring, and the windbreak effect of corn in summer, which reduces oat lodging.

Corn grain yields in a three-crop system show patterns similar to those in the two-crop system. Soybeans intercropped in strips wider than eight rows can outyield sole-cropped soybeans when grown in this three-crop system, due to the windbreak effect of the corn and lack of competition after harvest of the adjacent oats. The addition of a fourth crop not only adds to positive rotation effects, but also diminishes negative impact of the shading on the soybean strip. As a result, soybean strips with widths as little as five rows will yield equal to sole-cropped soybeans. The corn advantage still depends on strip width (Figure 5).

Selecting an alternative crop to replace the corn and soybean in any cropping system is a critical task. An alternative crop should be technically, socially, environmentally, and most importantly economically acceptable. These crops have to have agronomic compatibility and complimentary characteristics.

On many farms the absence of livestock limits the choice of crops. Inclusion of livestock increase the choice of crops, and allows multiple uses for each crop (i.e. corn for silage and oats for forage). Small farms with diverse production systems are more receptive to the strip intercropping system.

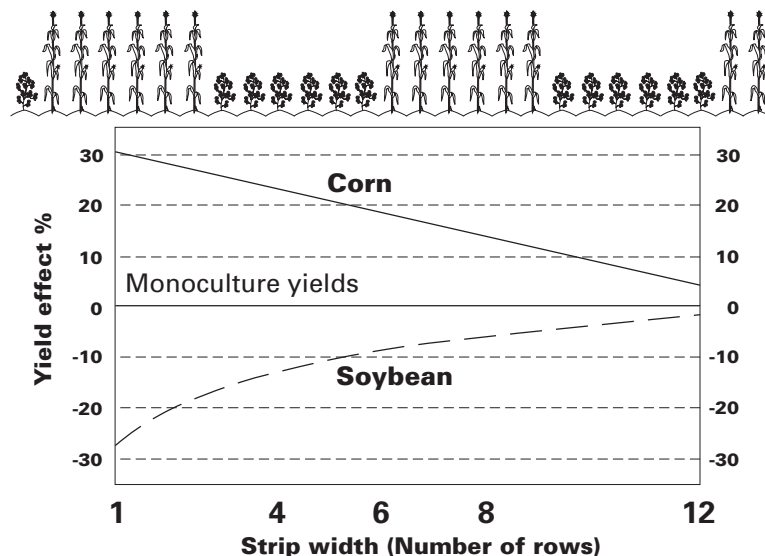


Fig. 2. Corn and soybean potential yield change with two-crop strip intercropping as strip width (number of rows) changes.

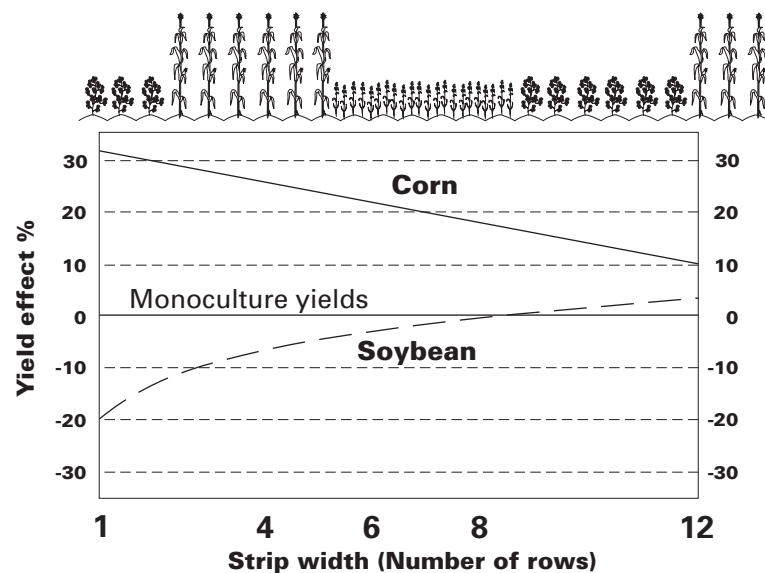


Figure 4. Corn soybean potential yield change with three-crop strip intercropping as strip width (number of rows) changes.



Fig. 3.1. The oat/corn border.



Fig. 3.2. The soybean/corn border.



Fig. 3.3. The oat/soybean border.

Fig. 3. Border rows within a three-crop strip intercropping system.

Effect of row position on crop yield

The higher yield of crops in a strip intercropping system is referred to as an edge effect. Crop rotation in this system causes an increase in yields in the long-term; however, the edge has short-term impact and is the main positive yield factor in strip intercropping. The positive edge effect in corn occurs mainly in the rows at the crop strip border (Figure 6). This positive effect may extend to the second outside rows; however, the yield in the center of strips wider than four rows is equivalent to sole-cropped corn. The negative edge effect in soybeans occurs in the two rows closest to corn, and yields increase farther from the border with corn. In dry years, soybean rows adjacent to early seeded oat strip yield less than any other rows. Small grains such as oats have increased yields at the crop edge, due to the early-season lack of competition. Mechanical cultivation of the corn and soybeans becomes critical to maintain the positive edge effect of the oat strip. Crop management and rainfall will alter the position effect and border interaction impacts.

Strip direction and crop orientation

The direction of intercrop strips is ultimately determined by topography (Figure 7). Ideally, strips run perpendicular to the slope so that the small grain strips can trap eroded sediment and reduce runoff. Strips perpendicular to wind direction will maximize the windbreak effect of corn, influencing the microclimate experienced by other crops.

Strip intercropping benefits are maximized when the strips run north-south rather than east-west. East-west strips in Iowa, where the summer solar azimuth angle is approximately 70 degrees, tend to shade the north edge of each corn strip and the south edge of each soybean strip, reducing border benefits. This shading has less effect on the growth of oats, but may delay the drying of mature oats. North-south strips tend to yield higher in the east than west border rows. This is due to the higher rate of photosynthesis during cooler mornings, when sunlight is striking the eastern edge, than during the hot afternoons, when sunlight striking the western border may not be fully used, due to moisture

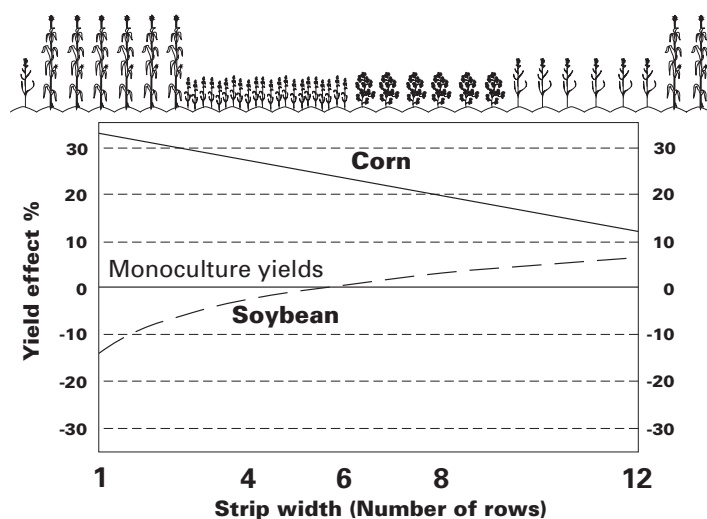


Figure 5. Corn soybean potential yield changes with four-crop strip intercropping as strip width (number of rows) changes.

stress and wilting. Soybean in north-south strips often yield better on the west border, where they are shaded from the afternoon sun by corn.

Crop orientation may complement and improve the effect of strip direction, for example, when strips have a north-south direction, planting soybeans on the east side of the corn strip benefits both crops (Figure 9).

Agronomic challenges

Plant population and varieties

It has been suggested that the increased light availability in the corn border rows should be met with a greater plant population and nitrogen supply than in the center of the strip or in sole-cropped corn. While the additional nitrogen requirement has been demonstrated in research plots, there appears to be little advantage to using populations much greater than 30,000 plants per acre. While the optimal population may be slightly above this amount, it has not yet been pinpointed in research. Different corn varieties have also not been compared in extensive trials, although some on-farm systems currently plant multiple varieties within the corn strip.

Pest Problems

In strip intercropping, there are both mechanical and chemical challenges to weed control. Equipment must be the appropriate size for each strip, and strips must be precisely placed to avoid overlaps or dead space between crops. Ridge-till may help with the latter challenge. Proper herbicides for each crop must be selected in case of drift. Differences in light availability across a strip can favor or discourage particular weed species, a factor that further complicates selecting an appropriate herbicide.

The extensive border between crops found in strip intercropping can provide yield advantages, but they can also provide niches and entry points for insects. Insect pest populations may shift according to the range and availability of feeding, mating, and egg-laying ground. Corn stalk borers (Figure 9) and corn root worm may present greater challenges than in continuous corn fields. Pests, such as soybean leafhoppers, may move into the corn strip to feed on damaged plants, and grasshoppers may take advantage of oat strips for entry into the field or egg laying sites.

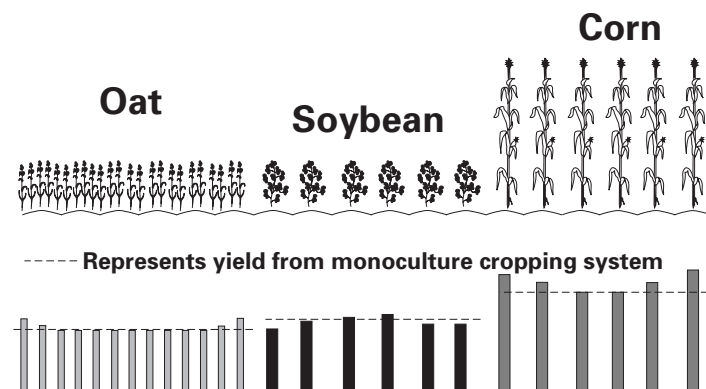


Fig. 6. Yield comparison of a three-crop strip intercropping with monoculture cropping as affected by row position.

Water quality and strip intercropping

Soil management methods such as conservation tillage are appropriate when the strips are rotated annually. Ridge-till, in particular, reduces surface runoff through soil surface and residue management (Figure 10). The presence of multiple crops in a single field reduces the amount of herbicide or fertilizer applied to that field at any one time. Hence, there is a lower risk of surface water or groundwater contamination in case of a heavy rain immediately after application.

Small grain strips have the added advantage of slowing surface runoff, thus reducing soil and chemical loads and improving water quality. The resilient stems of the small grain plants create friction, reducing the carrying energy of the runoff, allowing sediment to settle and chemicals to infiltrate into the soil. It is important, though, that the small grain strip be maintained to prevent concentrated (channel) runoff flow, which can overwhelm the strip. Among several cropping systems at the Iowa State University Northeast Research Center at Nashua, strip intercropping had the lowest nitrate-N concentration (<7 mg/L) in subsurface drainage water. Research in southwest Iowa indicates that soil erosion losses with no-till strip intercropped corn, soybean, and winter wheat is at least as good as continuous no-till corn on slopes of 12-14 percent.

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Fig. 7. Strip direction following contour line.

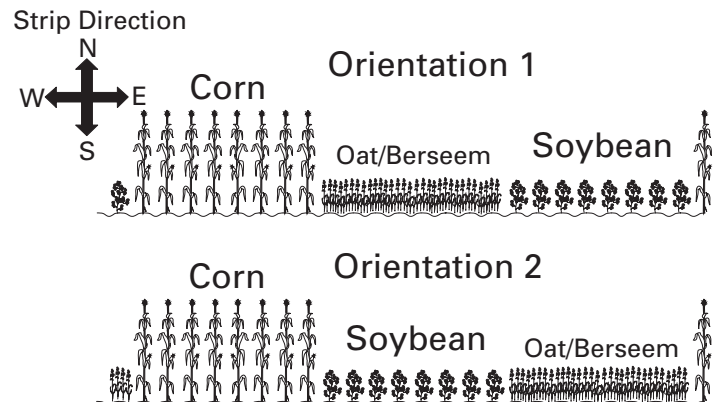


Fig. 8. Three-crop strip intercropping with different crop orientations.



Fig. 9. Corn stalk borer migrates into strip borders from previous year's corn residues. (Photo courtesy of Marlin Rice.)



Fig. 10. Strip intercropping (right) reduces runoff and soil erosion compared to untilled soybean ground (left).