Sustainable Agriculture Farming Systems Project

University of California, Davis

January 1997 | Volume 1 Issue 2

Low-Input Corn Production Yields Good Crop, Better Returns and Improved Soil Quality

The SAFS project compares conventional, low-input, and organic management of a 4 year, 5 crop rotation. The rotation consists of processing tomatoes, safflower, field corn, and either wheat (conventional) or winter legume/cereal mix (organic and low-input), double cropped with dry beans. Mineral fertilizer is applied to the conventional system; however, manures and cover crops are used exclusively in the organic system. Winter cover crops are grown in the low-input system, but the ensuing cash crop receives reduced amounts of supplemental fertilizer during the growing season.

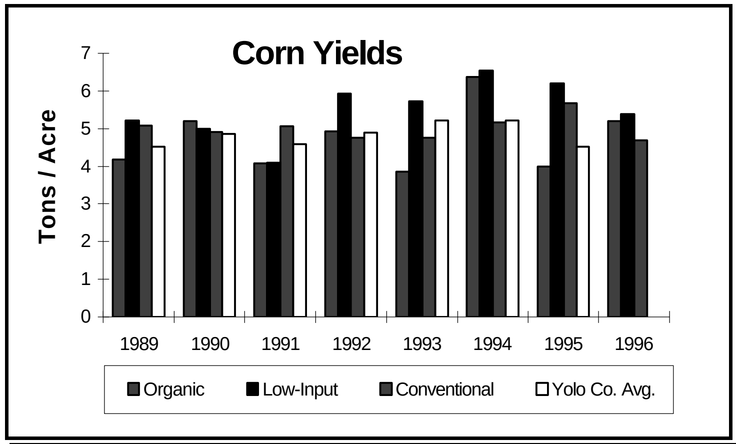

Fig. 1: SAFS Corn Yields in three different management systems vs. Yolo County averages.

Introduction

Field corn is an important crop in the Sacramento Valley. With over 80,000 acres grown annually, it is often included in rotations that emphasize high value crops such as processing tomatoes. During the last eight years, the Sustainable Agriculture Farming Systems (SAFS) project has been comparing yields among conventional, low input, and organic farming systems in order to help determine the most efficient practices for growing field corn. Following the refinement of system-specific production practices, the low-input corn system has had the highest yields for five out of the last seven years. The low-input corn yields were generally higher than both the conventional system and the Yolo County average, and provided the highest economic return of all three systems. The exemplary performance in the low input system suggests this system has advantages that are not present in the conventional system, which may be associated with the cover crop grown during the fallow period.

Production Practices

For conventional corn production, all ground work is completed in the fall; safflower residue is mowed and incorporated by stubble discing to a depth of 6-8 inches, and the plots are then chiseled to 18 inches and ring rolled. Plots are leveled with a tri-plane and shaped into 30 inch beds, which remain fallow for the winter. Immediately preceding planting in the spring, the beds are lightly tilled. Full season maize varieties typical of the Sacramento Valley are chosen, and the planting date is timed to coincide with sufficient soil moisture for germination without supplemental irrigation. Nitrogen fertilizer is applied at planting, and a second increment is applied as a sidedress between the five and seven leaf stage. A total of approximately 200 pounds per acre of nitrogen is applied to conventionally grown corn in the SAFS project.

In the low input and organic systems, lana vetch is planted in the fall. This winter cover crop is planted following incorporation of the safflower residue and after pre-irrigating with sprinklers. Approximately two weeks prior to spring corn planting, the cover crop is mowed and incorporated to a depth of 6-8 inches using a stubble disc. Another pass is made with a residue disc roller in order to further break up and mix the cover crop residue. In the organic system, manure is spread and incorporated with the cover crop and the beds are shaped. Planting corn after the cover crop usually requires pre-irrigation. To reduce weed pressure, early cultivation is used in the organic system, whereas cultivation and modest herbicide applications are made in the low-input system. The low-input system usually receives 80-120 lbs. of supplemental nitrogen fertilizer as a sidedress at the five leaf stage. This is a 40-60% reduction compared to the amount of mineral fertilizer applied to the conventional system.

"Best Farmer" Management

During the first three years of the project, production practices were evolving, and the SAFS project participants changed management strategies as they learned the most economically and environmentally appropriate farming methods for each system. For example, in 1991 the reduced yields in the low-input and organic systems were likely a result of inadequate incorporation of the cover crop. Consequently, after 1991 all cover crops have been incorporated to a depth of 6-8 inches. Beginning in 1992, a modest amount of supplemental mineral fertilizer, instead of manure, was applied to the low input system. These changes in the production practices are believed to be the most significant reasons for the increased yield in the low-input system. Since 1992, producizer applied can be reduced by 30% to achieve maximum yields. However, the benefits derived from the cover crop appear to go beyond nitrogen substitution. We believe the use of the cover crop improves soil structure, increases water infiltration and enhances nitrogen uptake efficiency.

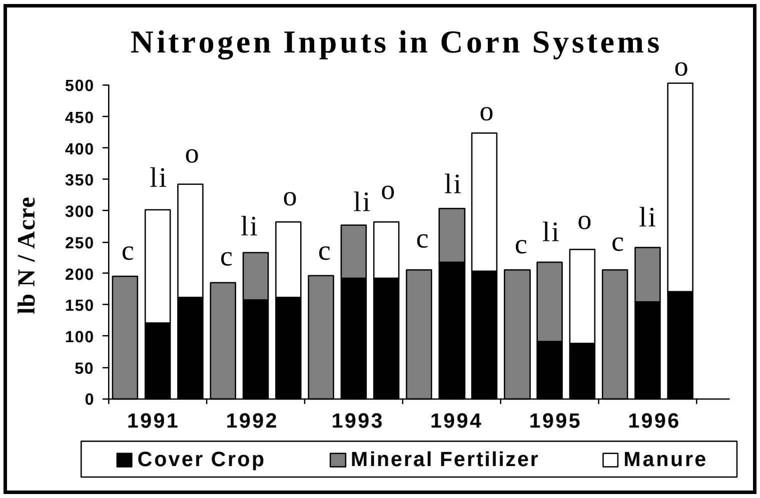

Fig. 2: ***c = Conventional; li = Low Input; o =***

tion practices in each system have been relatively consistent over time.

Fertility

In order to help identify the reason for the variation in yields between the systems, extensive plant tissue and soil data were collected in all three farming systems from 1993 to 1996. To determine nitrogen availability and uptake, samples of the lower portion of the corn stalk were collected at various growth stages for nitrate analysis. Soil samples were also taken for nitrate analysis from 0-6 and 6-12 inches. In addition, total nitrogen uptake was determined at harvest from nitrogen analysis of the grain and biomass.

The yields in the organic system have been the least consistent. Heavy weed pressure appears to have contributed to a yield decline in 1993 and 1995. However, the plant tissue and soil data suggest that the reduced yields may be more closely related to soil nitrogen availability. During these years, measurements indicated low soil nitrogen availability in the organic system. In 1994 and 1996, when the yields for this system were comparable to the low input system, nitrogen data indicated higher soil nitrogen availability. These fluctuations of soil nitrogen availability in the organic system demonstrate the challenge of matching nitrogen release, from both cover crop residue and composted manure, with the peak nitrogen requirements of the crop. Generally, the organic system amendments were often insufficient in meeting the high nitrogen demand of corn during its specific peak nitrogen uptake period.

In the conventional system, stalk nitrate results showed above-optimal levels of nitrate indicating sufficient nitrogen availability. Despite lower yields relative to the low-input system, the crop is receiving adequate nitrogen. The accumulation of nitrate in the stalk may be an indicator of insufficient moisture, which would suggest that lower yields in the conventional system are due to other factors, such as limited water availability at critical growth stages.

Combining useful features from both the organic and conventional systems, the low-input corn receives adequate nitrogen, moisture, and weed management. In the low-input system, the cover crop plays an essential role in providing nitrogen and enhancing water availability. Although the cover crop does not provide enough nitrogen for optimal yields, mineral fertilizer is applied as a supplement. The cover crop does provide a significant amount of nitrogen however, so the amount of mineral fertil-

Water Availability

Conventional corn yields have been consistent and slightly higher than Yolo County averages throughout the experiment, but not as high as the low input system for the last five years. In 1994, infrared aerial photographs indicated water stress in the conventional plots during grain fill. In order to develop an explanation for these differences, intensive soil water monitoring was implemented and soil physical and chemical properties were measured in all three systems starting in 1995.

Soil water content of each plot was measured using gypsum blocks placed at depths of 12, 24 and 36 inches. Data show that in the conventional system, water penetration decreased as the season progressed. As a result, the irrigation schedule was modified so that the conventional system received water twice as frequently as the other two systems for the duration of the 1995 corn season. Despite this modification, the total amount of water applied over the season was still less, and the profile was never recharged past 18 inches of depth.

Soil measurements of resistance, taken with a cone index penetrometer down to 15 inches, indicated a zone of compacted material in the subsoil of the conventional system. From 10-15 inches, resistance in the low-input and organic systems decreased, and the resistance in the conventional system increased. This compacted zone may have been caused by

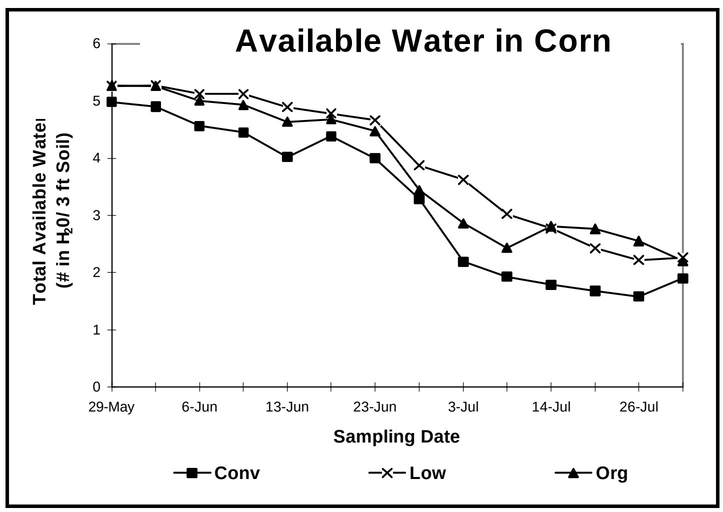

Fig. 3: Total water available measured in 3 SAFS corn systems as no. of inches of water/3 ft of soil

spring planting into higher moisture when the ground was wetter, even though ground preparation and beds were completed under dry conditions the previous fall. The low input and organic systems are considerably less moist during spring incorporation and bed preparation, because water has been extracted by the cover crop.

Based on measurements of furrow salts, all three systems had a lower than optimal Ca:Mg ratio. However, the ratio was much lower in the conventional system. High soil Mg may result in the physical disintegration of soil aggregates and the chemical dispersion of clay particles, both of which result in reduced soil porosity. This suggests that the decreased water infiltration in the conventional system may be associated with greater soil surface sealing and crusting. Irrigation water samples showed a Ca:Mg ratio of .5, suggesting that these high levels of Mg in the water may exacerbate the poor ratio in the soil as the season progresses. It is possible that the annual additions of cover crop and manure biomass carbon in the organic and low input systems maintain better soil aggregate stability and mitigate the effect of the high Mg in the irrigation water and the tendency toward crusting.

Although conventional corn yields have been consis-

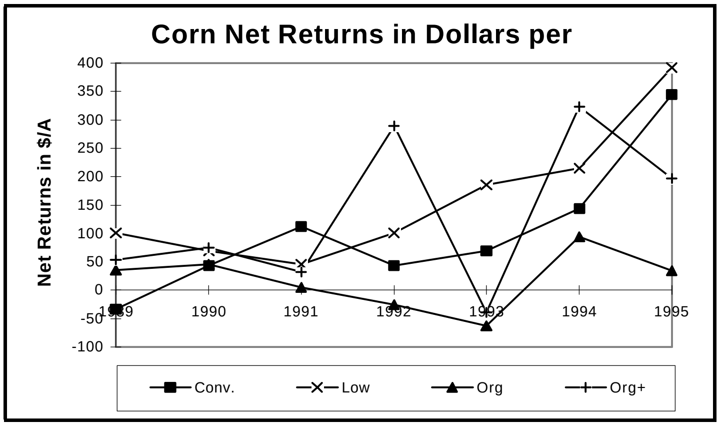

Fig. 4: Economic Net Returns are calculated for each system by subtracting the cost of production from the gross returns. Organic returns are calculated using conventional market prices (Org) and Premium market prices (Org+).

tently higher than Yolo county averages, this system may eventually require additional inputs. The addition of soil amendments or increased field operations may be necessary to improve water infiltration. While increased irrigation frequency appears to have improved water availability in the conventional system, it could also lead to other complications. The reduced water infiltration and compaction may result in consistently high moisture in the upper surface profile and higher disease susceptibility.

Summary

Although our data have not yet explained the mechanism for differences in water infiltration, the annual addition of a cover crop appears to improve water infiltration and reduce soil compaction. It is possible, that the use of the cover crop maintains better soil structure through physical and chemical means, and reduces impediments to water movement through the root zone. In addition, improved water infiltration results in higher nitrogen efficiency, thereby allowing reductions in mineral fertilizer without affecting yield.

The consistently higher yields of low input corn, compared to the conventional system, has important implications for the adoption of new corn production practices in this region. Yield and economic advantages of the low-input system indicate that cover crops appear to provide sufficient nitrogen for the early season requirements of corn. The sidedressed addition of nitrogen fertilizer prior to the peak uptake period supplements the nitrogen in the cover crop to provide adequate season-long fertility. These practices reduce the amount of mineral fertilizer applied by 50% of the recommended rate, and should reduce the potential for leaching and groundwater contamination.

In addition, the low input corn system has had the highest economic returns of the three systems since 1992. Thus, field corn grown in the Sacramento Valley, using a combination of cover crops and supplemental fertilizer, is an agronomically, economically, and environmentally viable component of more sustainable crop production systems.

SAFS Outreach and Education

A corollary objective of the SAFS project is to widely disseminate results from the studies through published works, conferences, workshops, and field days. In 1995, an Information Specialist was hired to coordinate the outreach component of the project. Grants were secured through the Professional Development Program (PDP) of USDA-SARE (Sustainable Agriculture Research and Education) to fund the position and the educational events and materials.

A series of four intensive workshops was held in 1995-96, in which a total of 317 agricultural professionals received in-service training. These participants included representatives from Cooperative Extension, USDA-NRCS, and various university and government sectors. Since the SAFS project is a research-based project, it functions as both a demonstration trial and a living laboratory for workshop participants. Participants attended lectures, laboratory and field sessions in which recent SAFS project results were discussed. Also, tools and methods for assessing sustainable cropping systems were presented. Educational materials were distributed at all workshops, which included several research publications, various tables and graphs, resource lists for alternative management methods, fertility management tools and methods, as well as samples of cover crop seed and inoculants.

The SAFS project has sponsored eight annual summer field days so far, each attended by over 125 participants. These included growers, farm advisors, international visitors and scholars, as well as students from throughout the state. These field days consist of a field tour, update of recent findings, and several laboratory demonstrations.

A wide variety of educational materials have been produced, including a slide show, video, quarterly newsbulletin and website. The slide show presents an overview of the project, including the goals, methods and experimental design, with general agronomic and economic results generated over the last eight years. A video of the SAFS project, which will be available by February 1, 1997, includes an overview of the project, the experimental design, the participatory research process as well as all current findings in the project.

The SAFS webpage is posted at:
http://agronomy.ucdavis.edu/safs/home.htm

The SAFS webpage includes the project description, experimental design, publications and current education and outreach events. Several other URL links are posted on the page, providing a gateway to over fifteen other Sustainable

SAFS Project Participants

The SAFS Project Newsletter is funded by : USDA-SARE
(Sustainable Agriculture Research and Education)
Professional Development Program
For additional information contact SAFS Information Specialist
Julie McNamara at 916-752-8940 or email:jrmcnamara@ucdavis.edu

Sustainable Agriculture Farming Systems Project
Dept. of Agronomy and Range Science
University of California, Davis
Davis, CA 95616