AN EXPERIMENTAL APPROACH TO DETERMINE THE ECONOMIC INCENTIVE FOR BREEDING CORN, COTTON, AND SOYBEAN CULTIVARS ADAPTED TO REDUCED-TILLAGE SYSTEMS

S.H. Moore and J.L. Kovar[1]

ABSTRACT

Crop cultivars now being grown in no-till production systems were developed by selecting for performance in conventionally tilled environments. In order to maximize production of corn *(Zea mays* L.), cotton *(Gossypium barbadense* L.), and soybean *[Glycine max* (L.) Merr.] in a no-till environment, it may be necessary to select for performance under the same conditions. The economic incentive for developing cultivars to produce in no-till environments cannot be determined without measuring the genotype times tillage interaction using genotypes that have not been selected for previous performance in a specific tillage regime. The experimental approach outlined here for determining the potential for improving performance in no-till systems is two-fold. The first experiment entails measuring crop and root growth rates, agronomic characteristics, and yield of commercial cultivars in conventional and no-till environments. Results from the first study should help identify cultivars with superior performance in no-till regimes and perhaps assist in establishing selection criteria for cultivar development programs. The second experiment measures the same performance parameters using randomly selected experimental strains that have not undergone selection in a specific tillage system. The second experiment should provide a reasonable measure of the genotype times tillage interaction for cultivars developed from crosses between elite parents, the source of most new commercial cultivars.

INTRODUCITION

The primary purpose of this article is to outline an approach for developing corn, cotton, and soybean cultivars that are better adapted to the relatively new cropping systems that are rapidly emerging in agriculture. Although there are many facets to consider in defining and attaining sustainable agricultural systems, there are at least two inherent requirements for any cropping system to survive in the long run which are not negotiable and must be met. The first is that the cropping system cannot be dependent upon consumption of non-renewable resources, and the second is that there cannot be a net toxic effect to the environment. Tbe urgency of developing alternative production culture for any single factor is determined by how scarce the resource is or the degree of toxicity to the environment. Francis (1991) outlined the dimensions of future cropping systems based on current trends, and characteristics of cultivars needed for those systems (Table 1).

In recent years, extensive effort has been made to conserve soil resources and reduce energy use by producing row crops with less tillage. Although significant acreage is now in reduced-tillage systems, nearly all crop cultivars now in production were selected for performance in conventionally tilled seedbeds (Triplett, 1986). Differences in performance of crop cultivars grown in tilled and untilled soil have been reported (Brakke et al., 1983; Newhouse and Crosbie, 1987; Triplett, 1986). In order to develop cultivars with improved performance in reduced-tillage systems, (1) growth factors influenced by tillage must be identified, (2) genetic variability for growth factors affected by tillage must be large enough to select for, (3) selection criteria to identify superior lines in segregating populations must be established, and (4) progeny with improved characteristics for reduced tillage must possess other agronomic traits, making for an adapted and competitive cultivar (revised from Kronstad et al, 1978). Francis (1990) emphasizes the need to carefully assess the potential for profit before establishing a long-term breeding program for new environments such as no-till regimes. This paper outlines an experimental approach for determining the genotype times tillage interaction for corn, cotton, and soybean cultivars.

PROCEDURE

Experiment 1- Determine the genotype times tillage interaction for commercial cultivars

The purpose of this experiment is to determine if commercial cultivars exist that display superior performance in no-till systems. Cultivars recommended

[1]Louisiana State University Agricultural Center, Baton Rouge, LA 70894.

Table 1. Dimensions of future systems and characteristics of cultivars for those systems.

Feature of system	Plant breeding solution
1. Reduced pesticide inputs and more regulations/environmental controls	1. Genetic tolerance/resistance to insects and pathogens, changes in crop species and modified cropping sequences
2. Higher energy costs, thus nutrient costs, and more regulations on groundwater and surface nitrate	2. Response to reduced rates of applied nutrients, greater nutrient use efficiency, more use of rotations
3. Reduced tillage and greater amount of crop residues, regulations on tillage	3. Increased seedling vigor, early stress (cold) tolerance, also tolerance to eco-fallow/zero-till planting
4. Higher pumping, equipment, and other costs of irrigation	4. Greater water-use effciency in crop species, stress (drought) tolerance, changes to more resistant/tolerant species
5. Greater recognition of benefits of specific location and system adaptation of cultivars	5. Greater number of commercially available cultivars, better data on specific adaptation to unique niches in system
6. Drastically increased use of crop rotations	6. Cultivars adapted to different rotation niches, more flexibility in maturity of available genetic materials, new crops available
7. Greater use of multiple species systems, especially crop mixtures, and relay planting	7. Greater range of maturities of cultivars available, greater potential for crop complimentation in new cultivars
8. Greater diversity in crops and potential products for a global marketplace	8. Breeding efforts to improve adaptation, productivity of a wider range of crops, and new introductions from wild species
9. Increasing concerns about crop nutritional quality	9. Breeding for nutritive value, low fat, easily prepared foods, fruits/vegetables for fresh market
10. Need for multiple purpose crops and plant types to promote feeding residues and nutrient cycling	10. Breeding crops with multiple functions, attention to grain and stover or by-products, root system morphology
11. Need for perennial cereals and legumes in compatible mixtures	11. Breeding and selection of cereals with pereuniality and ability to compete well in mixtures with legumes
12. Regulation of acceptable erosion levels	12. Systems/species maximizing soil protection while optimizing per-hectare crop productivity

(From Francis, 1991)

by the Louisiana Cooperative Extension Service will be used in field tests that will be conducted on a Norwood silt loam soil in the Red River Valley of central Louisiana. No-till and conventional tillage regimes will be used in the experiment. A split-plot design with four replications will be utilized with tillage system as main plot and variety as sub-plot. In the spring, burndown herbicides will be applied to conventional and reduced-tillage plots. The plow-pan layer of conventionally tilled plots will be fractured with a chisel plow on 19-inch centers, followed by two diskings and finishing with a do-all implement. The no-till plots will receive no tillage treatments. Crops will be seeded in 38-inch rows using a John Deere Max-Emerge planter, with fluted coulters if needed. Crop and root growth rates will be determined periodically. Weed species and populations will be recorded throughout the growing season. Yield will be determined at the end of the season, along with agronomic traits, followed by statistical and economic analyses. The test is planned for initiation in the 1993 season and to be conducted for 2 years.

Experiment 2 - Determining the genotype times tillage interaction for experimental strains with no previous selection

Experiment one will determine if commercial varieties now exist with superior performance in no-till systems. Since all the cultivars to be tested were selected (assumably) for performance in conventionally tilled systems, genetic variability for yield and other growth parameters between conventional and no-till systems may be underestimated. In order to get a more accurate measure of genetic potential for improvement, the genotype times tillage interaction should be measured using experimental strains that have not been selected for performance in a conventionally tilled system. The purpose of the second experiment is to determine the genotype times tillage interaction for strains derived from crossing elite germplasm. The strains will be obtained by randomly selecting 25 corn, cotton, and soybean lines in breeding programs where no selection for performance has yet occurred. Each experimental strain will be tested for performance in conventional and no-till environments using the same procedures outlined in experiment one.

In both experiments, crop and root growth analyses, along with additional agronomic traits, will be compared with yield performance in an effort to identify characteristics correlating with superior performance in no-till systems.

Subsequent programs for developing cultivars with improved performance in no-till systems

There are two general approaches for developing cultivars with improved performance in no-till production systems. The first is to simply select for yield in a no-till environment. The shortcoming of this approach is that the genotype times environmental interaction for yield is very large due to many factors other than tillage, and it may be difficult to make rapid progress. The second approach is to identify and select for genetic characteristics that contribute to yield in a no-till environment. Both approaches may be pursued simultaneously until the one giving more rapid advancement is identified. The experiments in this study are designed to facilitate both approaches. Once traits are identified that correlate with increased yields in a no-till system, the most efficient techniques for screening may be pursued.

Additional methods for increasing genetic variability and performance in a no-till system include utilizing exotic germplasm or gene transfer from other species. These more expensive and slower methods may become necessary if sufficient progress is not made utilizing traditional breeding techniques.

CONCLUSIONS

Crop cultivars now being grown in no-till production were developed by selecting for performance in conventionally tilled environments. The economic incentive for initiating breeding programs to improve performance in no-till systems cannot be determined without accurately measuring the genotype times tillage interaction. Research is needed to determine the genotype times tillage interaction using populations where performance has not been biased due to prior selection in a specific tillage regime. The approach outlined here is to randomly select experimental strains and compare their performance in no-till and conventional tillage systems. Correlating crop and root growth parameters to yield in a no-till environment may help identify selection criteria for cultivar improvement programs.

LITERATURE CITED

Brakke, J.P., C A Francis, L A Nelson, and C.O. Gardner. 1983. Genotype by cropping system interactions in maize grown in a short-season environment. Crop Sci. 23:868-870.

Francis, C.A. 1990. Breeding hybrids and varieties for sustainable systems. In Sustainable agriculture in temperate zones. Edited by C A Francis, C.B. Flora, and L.D. King. John Wiley and Sons, Inc.

Francis, C A 1991. Contribution of plant breeding to future cropping systems. In Plant Breeding and Sustainable Agriculture: Considerations for Objectives and Methods. Crop Science Society of America. Special Publication Number 18. p 83-93.

Kronstad, W.E., W.L. McCuistion, M.L. Swearingen, and C.O. Qualset. 1978. Crop selection for specific residue management systems. In W.R. Oschwald (ed.) Crop residue management systems. American Society of Agronomy, Madison, WI.

Newhouse, K.E., and T.M. Crosbie. 1987. Genotype by tillage interactions of S1 lines from two maize synthetics. Crop Sci. 27:440-445.

Triplett, G.B. 1986. Crop management practices for surface-tillage systems. In No-tillage and surface-tillage agriculture. Edited by M.A. Sprague and G.B. Triplett. John Wiley and Sons, Inc.