COMPARISONS OF ENERGY REQUIREMENTS FOR WEED CONTROL IN CONVENTIONAL AND NO-TILLAGE SOYBEANS

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ABSTRACT

Comparisons of energy efficiency were made between weed control programs in conventional and no tillage soybean (Glycine max (L.) Merr.) production. Two weed control systems of each of conventional and no tillage soybean production were compared. Calculated energy inputs and measured yields were used to determine the specific energy productivity for each weed control program. Both no tillage operations showed the highest overall energy efficiency with paraquat + oryzalin + metribuzin at planting and metribuzin + 2,4-DB directed post exhibiting the greatest energy productivity.

INTRODUCTION

The weed control programs in this study were selected to compare the energy efficiences of preemergence and directed post herbicides in no-till soybean production to that of preplant incorporated herbicides in combination with directed post herbicides or cultivation in conventional production.

Energy is an important factor in determining the efficiency of production. The importance of energy will increase in the future due to rising fuel costs and exhaustion of non-renewable resources. Energy conservation is a major reason for the increasing adoption of no tillage production systems.

There are many different energy units used throughout the world. One of the more common units is the joule which is of the metric (SI) system. This report will commonly refer to these energy units as megajoules (MJ) or 10^6 joules.

Fluck (1979) proposed that a new measure of productivity, the quantity of product per unit of input energy, be designated and that it be termed energy productdvity. In the SI system of units, a convenient measure of energy productivity is kilogrammes per megajoule (kg/MJ).

Energy productivity is specific for each agricultural product, location and time. That is, energy productivity can be used only to compare alternative production systems and energy conservation practices which result in the same product, at the same place, at the same time. By calculating the energy productivity of various production systems, the most energy efficient system may be determined.

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RESULTS AND DISCUSSION

Results from these four weed control programs indicated that the no-tillage operations produced larger yields and required less energy input than the conventional operations. Therefore, the no-till production systems showed greater efficiency from an energy point of view due to larger values of energy productivity.

Many explanations exist for no-tillage efficiency. Robertson and Prine (1976) and Triplett and Van Doren (1977) listed numerous advantages:

(1) Less fuel is required due to fewer and less energy-intensive field operations.

(2) Higher yields often result, particularly in dry land farming and on well-drained land. Evidence of this report supports the above statement.

(3) Less time and labor are required.

(4) Land use may be intensified.

(5) It is possible to farm lower quality land.

(6) Less erosion occurs.

(7) Moisture is conserved.

(8) Soil structure may be improved.

(9) There is lower investment for machinery.

The no-till weed control program that exhibited the greatest energy productivity was the combination of paraquat + oryzalin + metribuzin at planting with metribuzin + 2,4-DB directed post. This herbicide program produced an efficiency rating 21.7% greater than that of the highest yielding conventional program and 27.3% greater than that of the lowest yielding conventional program.

The no-till preemergence application of paraquat, alachlor, and metribuzin contributed the second highest energy productivity. This weed control program was found to be 17.8% greater than that of the highest yielding conventional program and 23.7% greater than that of the lowest yielding conventional program which contained two cultivations.

Green and McCulloch (1976) stated that, in general, at least two mechanical weeding operations are required to achieve the effect of one chemical treatment. This statment is supported by the poor performance of the conventional program which contained two cultivations. It produced the lowest yield while requiring the greatest total energy input. When compared to the directed post-treatments in conventional production, the mechanical weeding again proved to be the least efficient. This comparison supports the statement that chemicals are an efficient use of fossil fuel.

The purpose of this research was to determine the energy requirements of various weed control programs in no-tillage and conventional production of soybeans and to compare their energy efficiencies.

MATERIALS AND METHODS

Field experiments to evaluate the energy productivity of weed control programs in no-till and conventional soybean production were initiated in June of 1979 at the Agricultural Research Center located in Jay, Florida. The soil type was a Tifton fine sandy loam. Preplant incorporated and preemergence herbicides were applied during the first week in June with the directed-post treatments applied August 1. Soybeans yields for these four weed control programs were obtained in the fall.

The energy inputs for manufacturing soybean herbicides are given in Table 1. This energy input is the product of the energy requirement for manufacturing times the application rate. The weed control programs in no-tillage and conventional soybean production are listed in Table 2. The no-till programs consist of preemergence applications with one program having additional directed-post treatments. The conventional programs include preplant incorporated treatments with the first program containing two cultivations and the second having directed-post treatments. The itemized energy inputs include the energy required for herbicide production, incorporation, cultivation, and application of directed-post treatments. The energy inputs for preplant and preemergence application are included with the incorporation and planting operations.

When examining energy productivity, all inputs of production must be considered. For conventional soybean production, the total energy input less the energy required for herbicide production, application, incorporation and cultivation equals a base energy input of 15,164 MJ/ha. The base energy input includes energy for fertilizer, fungicides, insecticides, labor, and machinery. This value must be added with the individual weed control inputs to give an accurate estimate of the total energy input.

No-till production systems require less energy inputs of production. Fluck and Baird (1980) state that fuel reductions result in an average saving of 1170 MJ/ha. Lower labor requirements also result in a decrease in energy consumption. Elimination of two field operations might reduce labor inputs by one hour per hectare or labor energy requirements by about 75 MJ/ha. Lower energy requirements for less machinery will be in the order of 100-200 MJ/ha. Total energy reductions for limited tillage as compared to conventional cultivation may be in the order of 1395 MJ/ha for the base energy input. This reduction of energy consumption in no-till production results in a base energy input of 13,769 MJ/ha as compared to 15,164 MJ/ha for conventional production systems.

The energy productivity (Table 3) is calculated by dividing the yield (kg/ha) by the total energy input (MJ/ha). Fluck and Baird (1980) state that energy productivity is intended to and can serve as an evaluator of how efficiently energy is utilized in production systems yielding a particular product. This value illustrates the quantity of soybeans produced per megajoule of input energy.

The findings of this study strongly support the advancement of herbicide weed control programs in no-tillage soybeans over that of conventional tillage practices. The higher energy productivity of weed control in no-till soybeans illustrates the effectiveness of no-tillage in combination with proper weed control programs.

LITERATURE CITED

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Table 1. ENERGY INPUT FOR SOYBEAN HERBICIDE PRODUCTION

Herbicide	Rate lb/A	Rate kg/ha	Energy Requirements MJ/kg	Herbicide[1] Energy Input MJ/ha
Paraquat	.25	.28	460	129
Trifluralin	.50	.56	150	84
Alachlor	2.0	2.24	280	627
Oryzalin	1.0	1.12	150	168
Metribuzin	.50	.56	410	230
2,4-DB	.25	.28	87	24

[1] Produat of energy requirement times rate of application.

Table 2. ENERGY INPUTS FOR WEED CONTROL PROGRAMS IN NO TILLAGE AND CONVENTIONAL SOYBEANS

Cultivation (one) - 390 MJ/ha
Application (one) - 73 MJ/ha
Incorporation (2-disc) - 750 MJ/ha

Weed Control Programs	Itemized Energy Inputs MJ/ha	Subtotal Energy Inputs MJ/ha
A. No Tillage		
(1) Paraquat pre +	129	
Alachlor pre +	627	
Metribuzin pre	230	986
(2) Paraquat pre +	129	
Oryzalin pre +	168	
Metribuzin pre +	230	
Metribuzin DP +	230	
2,4-DB DP	24	
Application (DP)	73	854
B. Conventional Tillage		
(3) Trifluralin ppi +	84	
Metribuzin ppi +	230	
Incorporation +	750	
Cultivations (2)	780	1844
(4) Trifluralin ppi +	84	
Metribuzin ppi +	230	
Incorporation +	750	
Metribuzin DP +	230	
2,4-DB **DP** +	24	
Application (DP)	73	1391

Table 3. ENERGY PRODUCTIVITY OF WEED CONTROL PROGRAMS IN NO-TILLAGE AND CONVENTIONAL SOYBEAN PRODUCTION.

Weed Control Program	Yield kg/ha	Total Energy[1] Input MJ/ha	Energy[2] Productivity kg/MJ
(1) Paraquat + Alachlor + Metribuzin	2345	14755	.1589
(2) Paraquat + Oryzalin + Metribuzin + Metribuzin + 2,4-DB	2439	14623	.1668
(3) Trifluralin + Metribuzin + Cultivations (2)	2063	17008	.1213
(4) Trifluralin + Metribuzin + Metribuein + 2,4-DB	2164	16555	.1307

[1]Conventional Tillage - 15,164 MJ/ha + Weed Control Input.
No Tillage - 13,769 MJ/ha + Weed Control Input.

[2]Energy Productivity $= \dfrac{\text{Yield kg/ha}}{\text{Total Energy Inputs MJ/ha}}$

= Quantity of soybeans produced per megajoule of input energy.