Field Equipment **PUBLICATION**

EVALUATION OF ONE-PASS TILLAGE EQUIPMENT VERSUS CONVENTIONAL TILLAGE SYSTEM

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Abstract

The incorpramaster[5] is a new one-pass tillage implement developed by Incorpramaster Inc., Modesto, CA was compared with a conventional tillage practice consisting of stubble disking and land planing for energy savings and timeliness advantage using a randomized block experiment on the University of California, Davis campus. Our results indicate that the Incorpramaster outperformed conventional land preparation practice in terms of both fuel consumption and timeliness advantage. Fuel energy savings ranged from 19% to 81% with a mean saving of 50%. Timeliness savings ranged from 67% to 83% with mean of 72%. Mean particle size created by the incorpramaster was comparable to that produced by the conventional tillage system.

Introduction

Efficient farm management has always been of prime importance to farmers. It has become even more important to the economic survival of farmers in recent years because of large increases in capital and operating costs. Thus, farmers are being forced to search for ways to maximize net return in order to operate within economic constraints and growing environmental concerns.

Greater profits can be achieved through either increased returns or decreased costs. This goal can be met by growing higher valued crops, producing more per acre, expanding acreage, or reducing input costs. Producing higher valued crops depends on factors over which producers have little or no control such as climatic

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[5] Mention of a trade name is not an approval of this product versus similar products by the researchers or the University of California, Davis.

constraints or market demand. Improved varieties, fertilization, irrigation, and better management have substantially increased production and will continue to do so in the future, but such changes usually occur on a much slower time scale. Expanding acreage is one means of increasing total profit, but land constraints and market restrictions make this option not viable.

On the other hand, the management concept of reducing costs without changing any other production parameters is very attractive. Land preparation prior to planting requires very high energy inputs and results in high operating costs. Thus, it seems logical to develop techniques to reduce land preparation cost.

Incorpramaster is a new one-pass tillage implement developed by Incorpramaster Inc., Modesto, CA. The manufacturer claims that one or two operations using this device can replace many operations commonly employed in conventional farming practices (typically two passes with a stubble disc and two passes with a land plane). This should translate into savings in energy, timeliness, and lead to reduced soil compaction.

The objective of the study was to compare the performance of a one-pass tillage equipment (Incorpramaster) with that of a typical conventional tillage system (two passes of a stubble disc followed by two more passes of a land plane) in terms of energy savings, timeliness advantages, and implications on soil compaction.

Literature review:

Due to growing concerns about the impact of agricultural production on the environment, the adoption of conservation tillage has been on the rise in the United States in the past few decades. Uri (1999) reported that the area planted to conservation tillage increased from 1% in 1963 to 37% in 1997 (Uri, 1999). Conservation tillage systems utilizes both new and proven techniques to reduce soil erosion, conserve moisture and soil structure, reduce energy input and production cost, improve land use, and reduce labor (Rask et al., 1967 and McClure et al., 1968).

According to Conservation Technology Information Center (CTIC, 1998), the use of conservation tillage system in the US, can save as much as 225 hours and 1750 gallons of fuel per year on just 500 acres. The fewer trips also save an estimated $2500 in machinery wear. This enables growers to farm more land and improve profitability. However, the biggest gain may be in the cumulative affect of increasing organic matter and improved soil quality.

Although, there has been significant increases in conservation tillage production systems in the United States during the past decade, less than 0.3% of annual row crop acreage in California's Central Valley is currently farmed using CT practices (Mitchell et al. 2000).

The conventional crop production system in this region utilizes highly intensive crop production practices that comprise of 9 -11 tillage operations for pre-plant field preparation at a cost of about 18 to 24% of total production cost (Mitchell et al., 2000). Studies by Carter (1998, 1991, and 1985) over the last several decades have confirmed the potential to eliminate deep tillage and decrease number of soil preparation operations by as much as 60% which can reduce production cost while maintaining productivity in many crops.

These results clearly indicate the potential for adopting conservation or reduced tillage practices in California agriculture. The benefits include reduced energy, labor and thus total production cost in addition to reducing negative environmental impacts of intensive tillage.

Experimental techniques:

The field experiments were conducted at four sites (Plant Pathology, Pomology, Agricultural Practices, and Agronomy fields), at the University of California, Davis. Each of these sites had a different soil type making it possible to conduct tests in different soil texture. The test areas were 2.3, 2.6, 4.6 and 3.7 acres, respectively at the Plant Pathology, Pomology, Agricultural practices, and Agronomy experimental field sites. Furthermore, the soil texture at these four locations included Yolo fine sand loam, Brentwood silt loam, Yolo loam, and Yolo silt loam, respectively.

A randomized complete block experimental design with four blocks was selected to conduct field tests. Each block was divided into two plots and one of the two tillage treatments, the One-pass Tillage Equipment and the Conventional Tillage System, was randomly assigned to these plots. All plots were previously tilled to a depth of 18” with a sub-soiler. The sub-soiler was operated at 45 degrees to the length of the plot during the first pass. During the second pass the sub-soiler was operated at right angles to the direction of the first pass. A brief description of machinery and tillage system is provided in the next few paragraphs:

Machinery and tillage system:

Figure 1 is a photograph of the new one-pass tillage equipment, Incorpramaster, used in this study. Incorpramaster consists of five tillage tool sets in the following sequence from the front to the back (figure 2). According to the manufacturer these five units accomplish following tasks:

1. The *dyna drive* unit consists of two mechanically linked vangatriz rolls, with a gear ratio of 1:3 between the first and second rolls. The first roll is ground driven, which in turn drives the second unit. The main purpose of this unit is to loosen soil, break clods and mix stubble or pre-emergent fertilizer.

2. The18” diameter roller with *spiral reels* is a ground-driven unit useful to chop stubble, break clods and also mix soil or pre-emergent fertilizer. This unit is especially important to prevent long stubble from clogging the following rows of S-tines.

3. A *chisel unit* with four rows of 1/2” S- tines with 7” sweeps provides deep tillage, uniform soil mixing by eliminating rhizomes and creates consistent seedbed.

4. Two rows of 14” r*olling harrows* follow the S-tines. The pressure on these harrows can be easily adjusted for varying soil conditions using hydraulic cylinders. It also breaks clods and creates level seedbed.

5. A 9” ring roller on 7 1/2” tube provides a smooth-finished seed bed. The rings break clods and seal moisture and/or pre-emergent fertilizer.

The Incorpramaster was operated using a 385 HP, JD8870, 4 WD tractor. The equipment width was 18 feet and its operating depth varied from 6 to 8 inches depending on initial soil moisture condition. A typical Conventional Tillage System widely used in California consists of two passes with a stubble disk followed by two passes with a land plane. A 180 hp, JD 4840 tractor, was used for disking and planing operations. The stubble disk had an operating width of 12 ft. and depth of 6 to 8 in. The land plane had an operating width of 16.2 ft and depth of 1 to 2 in.

Field measurements

Fuel consumption and forward speed were obtained during field tests and subsequently analyzed to estimate the energy requirements and performance of both treatments. Cone index, soil density, and moisture content data were also obtained to quantify the effect of each treatment on soil compaction before and after tests. Tillage depth, clod samples, and photographs were used to evaluate the final soil condition.

A special device which consisted of a fuel pump powered by tractor battery, two 2-way valves, a graduated plastic tube was designed and built to determine the exact fuel consumption of each system. Figure 3 shows various components used in designing fuel consumption measurement system. In order to measure fuel level, the tractor was parked at the same location, a specially marked location in each field, before and after each test. The amount of fuel needed to return the manometer fuel level to that before the test was measured by weighing an external fuel tank.

Ten replicates of the time required to travel 200 feet along a straight line were taken for each treatment to determine average speed of operation. Also, for each treatment, ten measurements of cone index values were taken before and after the tillage operation, using a hydraulically operated, instrumented Cone Penetrometer installed on a 2010 John Deere tractor.

In order to determine the particle size distribution, five soil samples were obtained in each plot before and after every the test. These samples were analyzed using a set of 3”, 1”, 3/8”, No 4, 10, 20, 60, and 100 sieves and a mechanical shaker to determine fraction retained on each sieve. These fractions were used to determine geometric mean diameter of soil particles. The procedure used for finding geometric mean diameter was a modification of the method for determining fineness of feed materials reported in the ASAE Standard S319.1[1].

Five soil samples were taken in each plot using a volumetric core ring to determine soil moisture content and bulk density. The oven-dry method was used to determine the density and moisture content. Three more core samples were taken after each test to obtain final bulk density and moisture content data.

Results and discussion

Fuel Consumption: Table 1 lists the fuel consumption data obtained along with expected fuel savings due to the one-pass tillage system, Incorpramaster, compared to the conventional tillage practice. An analysis of variance (ANOVA) of the field data based on a randomized block design showed that Incorpramaster required significantly lower amount of fuel (Tables 1 and 2). The savings ranged from 19% to 81% with a mean of 50%. The higher fuel savings obtained in the Pomology field was attributed to the only one pass of the Incorpramaster that was necessary in this field to create a comparable soil condition to conventional system (Table 1). Note that two passes of the Incorpramaster were needed in all other test sites.

Timeliness: Table 1. summarizes the time required to till a unit area and timeliness advantage for Incorpramaster over the conventional practice. In estimating the time requirements we have adjusted the time required for stubble disking for the case in which JD 8870 instead of JD 4840 would have been used. JD 8870 was used for operating the incorpramaster which could have handled a 18ft stubble disk rather than the 12 ft. disk used with the JD 4840 tractor. The results indicate that incorpramaster requires significantly lower amount of time compared to the conventional tillage practice (Tables 1 and 2). The timeliness

[1] We also obtained pictures of experimental plots to visually evaluate the final soil condition. However, this technique turned out to be unreliable since the effect of each treatment extended to the full operating depth rather than being limited to the surface only.

advantage for the incorpramaster ranged from 67% to 83% with an impressive mean of 72%.

Cone index values: Table 3 lists the cone index data obtained in all the plots before and after tillage treatments. Mean cone index values did not differ significantly either before tillage or after the completion of treatments (Tables 2). However, the mean cone index value in the tilled layer was significantly higher for Incorpramaster as compared to conventional tillage (Tables 2). The mean cone index value in the plots tilled by Incorpramaster was 179 psi compared to 114 psi found in conventionally tilled plots. These types of cone index values are not a concern in dry soil conditions prevalent during our tests. In wet conditions pressure in the hydraulic cylinders controlling the rolling harrows of the Incropramaster may need to be set to lower values.

Density and moisture content: Dry bulk density and moisture content data for the test plots are presented in Table 3. Neither the initial nor the final density or moisture content data significantly differed between two tillage practices. This indicates that the soil condition was uniform to start with and both practices resulted in similar soil conditions (Tables 3).

Operating depth: Table 3 lists the operating (tillage) depth in each of the test plots. Once again, the ANOVA on these depth data showed that the operating depth did not significantly differ from each other in the test plots (Table 2). Since the operating depth did not differ significantly between the two treatments, we felt it was unnecessary to correct the fuel consumption values for the respective depths of operation.

Particle size analysis: Table 3 presents the geometric mean particle sizes in various plots both before and after tillage. An ANOVA of these data indicated that mean particle size did not differ in the plots either before (initial conditions) or after tillage (Table 2) indicating that the both treatments resulted in similar soil conditions.

Conclusions:

Based on our field tests on the University of California, Davis Campus, we found that the Incorpramaster, a one-pass tillage tool, outperformed conventional land preparation practice consisting of stubble disking and land planing. Fuel energy savings ranged from 19% to 81% with a mean saving of 50%. Timeliness savings ranged from 67% to 83% with mean of 72%. Mean particle size created by the Incorpramaster was comparable to that produced by the conventional tillage system.

Acknowledgments

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LIST OF FIGURES

Figure 1.   One-pass tillage equipment (Incorpramaster)

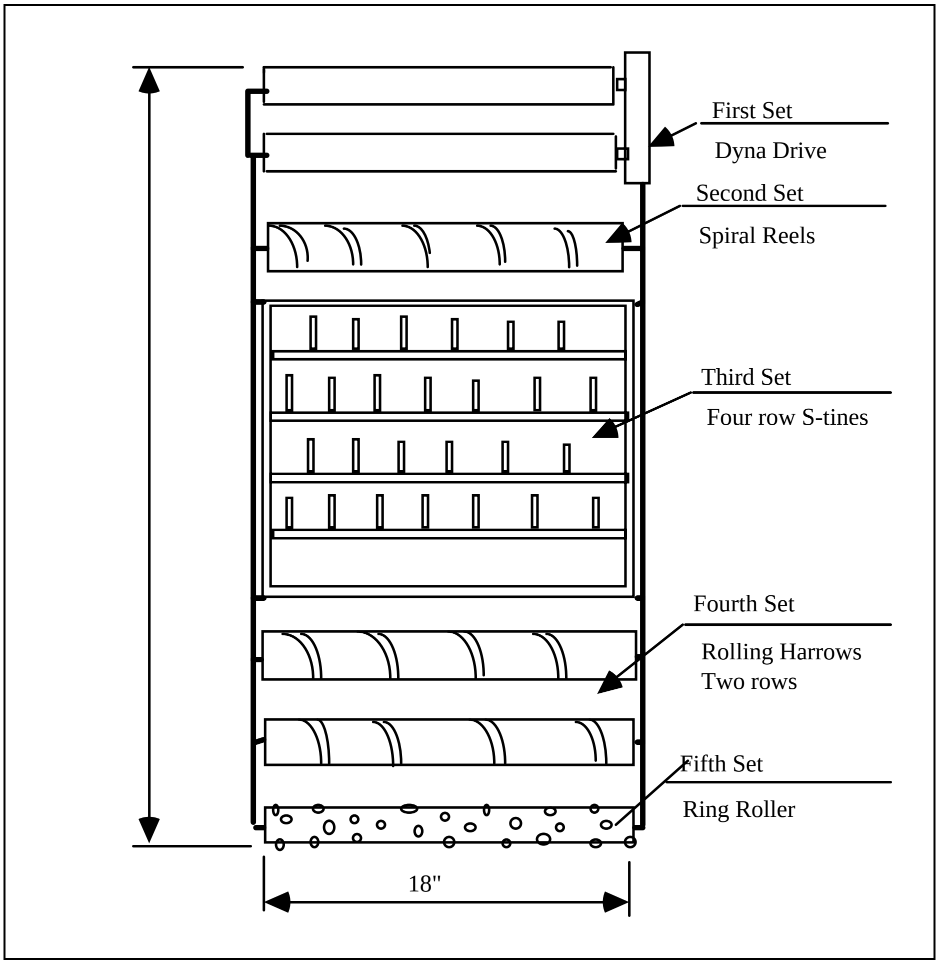

Figure 2. A schematic diagram of the One-pass tillage equipment, Incorpramaster, used in this study.

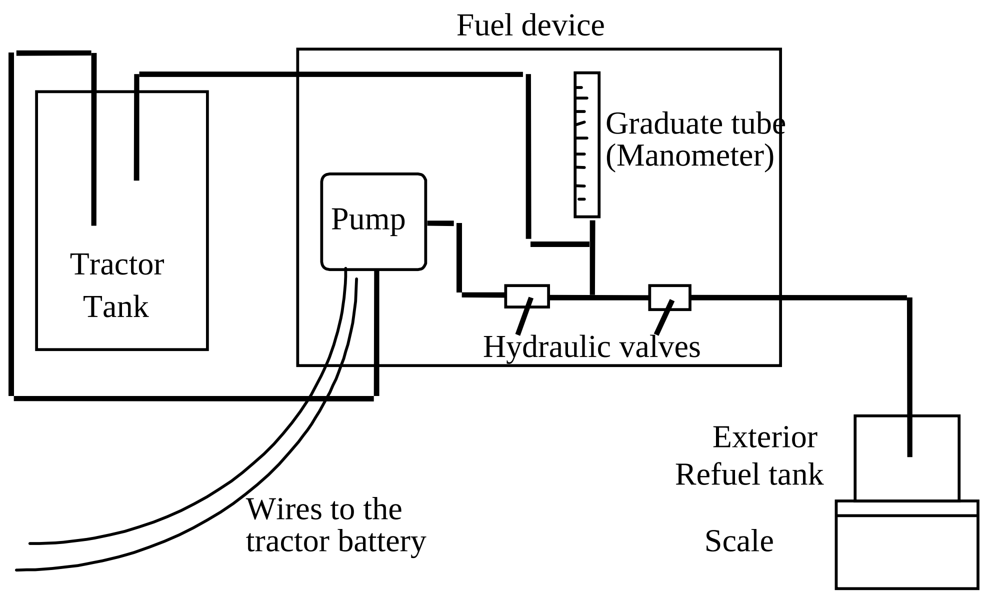

Figure 3. Fuel consumption measurement system