

USING OPERATION ANALYSIS to IMPROVE ROW-CROP MACHINERY EFFICIENCY



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Using Operation Analysis to Improve Row-Crop Machinery Efficiency

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THE ROLE of farm machinery is becoming more important in production of agricultural crops. This role becomes of special importance as machines become larger. Economic pressure demands that the farm operator use his machinery as efficiently and effectively as possible.

Engineers have long been interested in machinery-use problems and have used numerous approaches to solve them. Linear programming has been used by several researchers (2). Link (4,5) and Sowell (9) have used the network analysis concept and mathematical approaches as aids in selecting machinery and for determining machinery needs.

The importance of machinery use and field efficiency as related to economic agricultural production was recognized by Jones (3). Machinery capacity and field machine efficiency as related to field size, row length, and terrace systems have been studied at Auburn University (6,7). This work shows that field capacity of machines varies greatly from field to field.

Several agricultural engineers interested in machinery-budgeting or machinery-use programming have suggested a systems approach. Von Bargaen (11) discussed this technique in his work relating to harvesting alfalfa hay. Stapleton and Barnes (10) have also done some work with the systems-analysis concept.

Nearly all researchers dealing with machinery programming have been confronted with a common problem. This problem is the lack of reliable input data. Stapleton (10) cites it as a prob-

lem in his work. Abelson (1) in his editorial in *Science* also suggests this as one of the major problem areas. The results from machinery programming are only as good as the input data.

A machine operation can be no more efficient than the efficiency of the individual segments making up the total operation. Industry has recognized this fact and has used it as the basis for time and motion and operation analysis studies in factories. Research was undertaken at Auburn to examine the possibility of using the operation analysis concept to analyze field operations of row-crop machines. This also involved obtaining reliable input data which could be used as guides for comparisons in the analysis studies. The results of this study are presented in this publication.

RESEARCH STUDIES

The operation analysis research work was part of a machinery-needs-and-use study of row-crop machines. The field research work was conducted at the Agricultural Engineering Research Unit near Marvyn during a 4-year period. Fields used in the study ranged from 8 to 25 acres with rows 200 to 1,500 feet in length.

Time measurements for field operations were recorded. Long-time intervals were recorded by a time clock on a circular time chart and short time periods were measured with a stop watch and recorded by a research assistant in the field where the machine was used. The research assistant was stationed so he could observe the field operations but was far enough removed so as not to interfere with any part of the machine operation.

Field equipment used in the field studies was conventional row-crop machinery. The machine operators were of average ability and all had several years experience.

OPERATION ANALYSIS

If the operation-analysis concept is used to study machine operation in the field, some type of record of machine operation must be obtained. This is essentially a study of the total production system — machines, fields, and management.

An operation analysis involves three basic parts. The first is to obtain accurate time records of all activities relating to a specific machine operation in a field. An example of this would be a complete field-time record of a cotton planter in operation and would

TABLE 1. PLANTING OPERATION TIME RECORD 4-ROW PLANTER

Operation	Total time	
	<i>Hr.</i>	<i>Min.</i>
Total field operation time	8	0
Actually placing seed in ground	3	12
Adjustment and down time	0	24
Adding seed	0	31
Adding fertilizer	1	36
Adding chemicals and water	1	55
Turning time	0	19

include the increments of time related to each major segment of the total planting operation. Table 1 is an example of such a time record.

The second part of the operation analysis involves dividing the time record into the primary function and supporting functions as in Table 2. In a planting operation, placing seed in the ground is the primary function. The supporting functions include such items as adding seed and chemicals and row-end turning. In Table 2, the time for each component operation has been expressed as a percentage of the total field time. Expressing these values in per cent puts them in a more useful form for later use in the third part of the operation-analysis concept.

The third part of the operation analysis involves a detailed study of the information obtained in parts one and two. This would include looking at each segment of the operation to determine if the time for any individual segments appear to be excessive with respect to the total operation time. For instance, in the planting operation example shown in Table 2, each item in the primary function and the secondary functions would be examined.

After the questionable segments are identified, it is necessary to examine and analyze each of these segments in detail to determine why so much time is used. This analysis would take into

TABLE 2. PLANTER OPERATION ANALYSIS DATA 4-ROW PLANTER

Operation	Total field time
	<i>Pct.</i>
Primary function	
Actually placing seed in ground	40.6
Support function	59.4
Adjustments and down time	4.9
Adding seed	6.4
Adding fertilizer	20.3
Adding chemicals and water	23.5
Turning time	4.3

account the field physical conditions, the machines used, and any managerial decisions that might have influenced the time record. After a detailed analysis is completed, changes in future operational procedures would be recommended for those segments which show the greatest possibility for improving the efficiency of the total operation.

OPERATION ANALYSIS USE EXAMPLES

The value and use of operation analysis can be illustrated with the following examples. For the planting operation in Table 2, the support functions use 59.4 per cent of the total field operating time, including 43 per cent to add fertilizer, water, and chemicals. Renoll (8) lists some efficiency values obtained from efficient operations. For example, in efficient planting operations only 40 to 50 per cent was used for support functions. Based on this earlier work it seems the support functions time in Table 2 are excessive and should be examined for the cause. After the causes have been determined, remedies can be applied. In this example it would seem that the major problem is the flow of material to the planter.

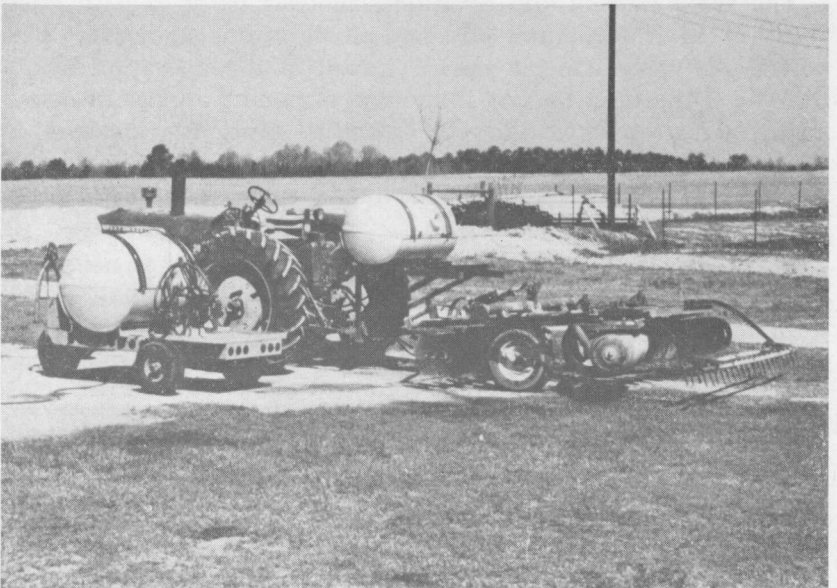


FIG. 1. In the use of the sprayer, correct planning for the handling of materials will increase machinery operation efficiency.

TABLE 3. PLANTER OPERATION ANALYSIS DATA 2-ROW COTTON PLANTER

Operation	Total field time <i>Pct.</i>
Primary function	
Actually planting cotton.....	45
Support function	55
Adding seed and fertilizer.....	8
Adjusting planter.....	26
Turning at row ends.....	21

Another example of the use of operation analysis is found in the data from Table 3. These data suggest two possible problem areas, field problems and management or supervision problems. Turning time accounts for 21 per cent of the total field time while planter adjustment amounts to an additional 26 per cent. Since these values seem to be excessive, the causes should be determined and remedied.

Turning time is influenced by row length. An acre of long rows has fewer turns than an acre of short rows. When turning time is excessive, the farm manager should examine field size, row arrangements, terrace layout, and row length to determine if changes can be made to reduce turning time and thus improve efficiency.



FIG. 2. When planting, long-row fields are more efficient for machinery use than short-row fields.

TABLE 4. OPERATION ANALYSIS DATA 1-ROW AND 2-ROW COTTONPICKER

	1-row Total time	2-row Total time
	<i>Pct.</i>	<i>Pct.</i>
Primary function		
Actually picking cotton.....	77.0	74.9
Secondary function	23.0	25.1
Turning time.....	6.6	6.3
Dumping time.....	10.2	14.3
Cleaning time.....	6.2	4.5

Turning time is also influenced by the physical condition of the turning area. Rough and uneven turn spaces require more machine turning time than smooth areas. Narrow or short turn spaces increase turn time.

The excessive planter adjusting time of 26 per cent suggests several management problems. These might include poor seed-bed preparation, improper planter maintenance which could cause excessive parts breakage, improper planter set-up before starting to plant, or improper operator training which could result in a trial-and-error approach to planter adjustment.

Planter maintenance, repair, calibration, and adjustment should be performed prior to the start of planting.

In analyzing some machine operations it is not always easy to determine which segments to study in detail. The operation analysis in Table 4 is such an example.

Since no specific item in the secondary function appears to be excessively high it is not likely that any great reduction in total time for these functions can be obtained. Dumping time might be a little high and should perhaps be studied in some detail.

SUMMARY

Operation analysis has been used to successfully analyze some row-crop operations and the machines involved. The procedure can be used to study the total machine operating system, including the specific machines, the fields, the interaction between the machines and fields, and the management of the machines. The procedure can also be used to examine suspected problem areas in material flow, field size and row arrangement, turn areas, faulty or improper service or maintenance of the machine, and misuse of the machine.

Data from efficient field operations can be used as guides for evaluating information from field operations being studied.

The operation-analysis concept appears to have considerable merit when planning for maximum machinery utilization. Farm managers can use this concept to help predict more accurately machine capacity for specific fields and thus better plan for efficient machine use. This concept is also helpful in projecting machine needs and sizes for handling a specific enterprise.

ACKNOWLEDGMENT

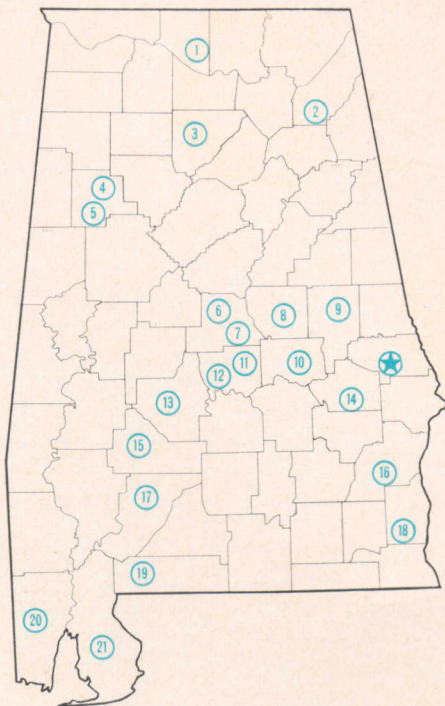
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