5. PLANNING FIELD OPERATIONS

CHAPTER OBJECTIVES:

- ***To introduce the reader to the process of planning and scheduling the field operations in such a way that the biggest profit is returned to the farm business;***
- ***To describe the importance of machinery size in completing the field operations within a given time frame;***
- ***To discuss the factors that influence machinery selection and size for the different field operations on the farm;***
- ***To determine the field capacity of the machinery system;***
- ***To discuss the different steps of planning and scheduling field operations.***

It is very difficult to put together an ideal machinery system. Because many of the variables are unpredictable, the goal of good machinery management should be to have a system in place that is flexible enough to accommodate a wide range of weather and crop conditions while minimizing long-run costs and production risks. To meet this goal several fundamental questions must be answered:

- Can the machinery perform adequately and reliably?
- Will crop yields and quality be affected by the dates of planting and harvesting?
- What are the factors that can influence the machinery selection?
- How large should the machinery be?
- What is the field capacity of the machines?
- How many field days are required for completing the operation?

5.1. MACHINE PERFORMANCE

Farmers can increase profits by selecting the right scale of equipment for their farm size, labor supply and tillage program. Machinery must therefore perform adequately and reliably under a variety of conditions to justify the capital investment. Tillage implements should prepare a satisfactory seedbed while conserving moisture, destroying early weed growth, and minimizing erosion potential. Planters and seeders should provide consistent seed placement and population as well as applying pesticides and fertilizers in a proper way. Harvesting equipment must harvest clean, undamaged grain while minimizing field losses.

The performance of a machine depends mostly on the skill of the operator, and on weather and soil conditions. However, differences among machines can be evaluated through field trials, research reports, and personal experience.

Once a particular type of tillage, planting, weed control, or harvesting machine has been selected, the question of size must be answered. Machinery, which is too large for a particular farming situation, will cause unnecessarily high machinery cost over the long run. Machinery, which is too small, may result in lower crop yields or quality.

5.2. PLANTING AND HARVESTING DATES

In many cases, crop yields and quality are affected by the dates of planting and harvesting. This represents a hidden cost associated with farm machinery. The value of these yield losses was referred to in previous chapters as timeliness costs. The scheduling of field operations therefore needs to be carefully planned within the time frames of planting and harvesting dates for a specific crop.

Long-term studies indicate that corn yields normally start to decline significantly when planting occurs after a certain date. The exact dates may vary from year to year. One reason for the declining yields of late-planted corn is that fewer heat units are available, influencing the rate of crop development.

There is some risk when planting too early. Replanting may occasionally be required, but the long-term benefits outweigh this cost. With the cost of energy increasing, the benefit of lower grain moisture levels at harvest from early-planted corn is likely to increase. The same can be said for many other crops.

Timeliness losses at harvest are due to more dropped ears, field shattering, and cracked beans. These losses must be balanced against the cost of artificially drying grain that was harvested at a higher moisture level than required for safe storage. Harvesting losses can also occur because the combining speed is too high or the machine is poorly adjusted.

5.3. FACTORS AFFECTING SIZE

Machinery operations must be based on the characteristics of each individual farm. Several factors influence machinery selection.

Crop area

As the farmed crop area increases, larger-scale machinery is needed to ensure that planting and harvesting are completed within the required time frame. An alternative is to acquire a second unit of some machines, if an additional tractor and operator are available.

Labor supply

The number of hectares that can be completed within each day is a more critical measure of machinery capacity than the machine width or hectares completed per hour. Increasing the labor supply by hiring extra operators or by working longer hours during critical periods may be a relatively inexpensive way of stretching machinery capacity. In addition, the cost of additional labor only needs to be incurred in those years in which it is actually used, while the cost of investing in larger machinery becomes fixed as soon as the investment is made. On the other hand, extra labor may not always be available when needed.

Tillage practices

The number of field days that is needed to complete planting depends partly on the number of separate operations that must be completed on each field. Reducing the number of tillage practices performed, or performing more than one practice in the same trip, effectively decreases the amount of machinery capacity needed to complete field operations on time. Machinery cost savings from reduced tillage must be compared to the possibility of increased chemical costs and effects on yields.

Crop mix

Diversification of crops tends to spread out the periods when timely completion of field operations is critical. For example, yield reductions due to late planting start occurring later for soybeans than for corn. Harvesting can also be completed over a longer time period. Thus, growing more than one crop reduces the amount of machinery capacity needed. However, it may be necessary to purchase additional types of machinery, especially for harvesting.

Weather

Weather patterns determine the number of days suitable for fieldwork in a given time period. Although actual weather conditions cannot be predicted far enough in advance to be an aid to machinery selection, past weather records can be used as a guide. Extension documents, listing the minimum number of field days expected for different periods of the year for specific regions are available in most countries. Machinery selection should be based on long-term weather patterns even though it results in excess machinery capacity in some years and insufficient capacity in other years.

Risk bearing ability and preferences

Year to year fluctuations in the number and occurrence of suitable field days cause timeliness cost to vary even when the machinery set, crop area, and available labor do not change. Investing in larger machinery can reduce the variability of total machinery cost by insuring that crops are planted and harvested on time, even in years in which there are fewer working days. The fixed costs of the machinery system will be higher with larger machinery, but they will not fluctuate as long as the machinery set doesnôt change. Farmers with high fixed cash flow needs may be willing to pay more (in higher fixed machinery cost) than others for the insurance of not suffering substantial yield losses due to late planting or late harvesting in certain years.

5.4. MACHINERY SIZE

One way to measure the capacity of a set of machinery is by the number of work days required to complete the field operations for the different enterprises. This

depends on the crop area, machinery operations performed, size of the machinery in use, and availability of labor.

In research that was conducted in the USA, total machinery costs for grain farms, including the value of timeliness losses, were estimated for a number of different machinery combinations. The effects of variations in the crop area, labor supply, and location were compared*.

The machinery set for which total costs were lowest was identified under different circumstances. In some cases, several machinery sets gave nearly identical minimum cost. In approximately 80% of the cases tested, the least-cost machinery sets were able to complete all tillage and planting operations in about 20 to 25 workdays.

A good rule of thumb for farmers who wish to have sufficient machinery capacity to reduce risk and maintain low total costs at the same time, is that they should be able to complete tillage and planting in about 20 workdays. Where less than one full-time person is available to operate the machinery, a goal of 25 to 30 days for completing planting and tillage will most often minimize costs. Farm businesses with 2 or 3 full-time machinery operators available could aim to complete this work in less than 20 days.

The machinery sets, which minimized total machinery cost, were most often able to complete harvesting of corn and soybeans in 25 to 30 field days. As with spring work, operators for whom risk reduction is important should use the lower end of this range as a goal, although yield losses from late harvesting are generally not as severe as from late planting.

A number of different machinery combinations may allow fieldwork to be completed in the same number of days. In putting together a machinery set, it is also important to correctly match machinery sizes and tractor power, as described in the previous chapter. Using tractors with power in excess of that required for the implement being pulled, results in inefficient fuel consumption while using too little power may cause faster engine wear.

Some farm businesses may not have a big enough crop area to justify a full line of machinery. This applies particularly for harvesting. In these cases, custom hiring or leasing certain machinery operations may lower total cost as well as

* *Experiment Station Special Report 85, Farm Machinery Selection in Iowa Under Variable Weather Conditions.*

providing more flexibility in the available machinery capacity.

5.5. FIELD CAPACITY OF FARM MACHINES

The working capacity of a machine is the rate at which it performs its primary function. The number of hectares that can be disked per hour or the tons of hay that can be baled per hour can measure this. Measurements or estimates of machine capacities are used to schedule field operations, power units and labor. It can further be used to estimate machine-operating cost.

The most common measure of capacity for agricultural machines is field capacity, expressed in hectares covered per hour. Theoretical field capacity is dependent only on the full operating width of the machine and the average travel speed in the field. It represents the maximum possible field capacity that can be obtained at the given field speed when the full operating width of the machine is being used. It can be calculated with the following formula, derived from formula [4.1]:

$$\textit{Theoretical field capacity}(\textit{ha/h}) = \frac{\textit{Speed(km/h)} \times \textit{Width(m)}}{10} \qquad \textbf{[5.1]}$$

A machine cannot maintain its theoretical field capacity for very long periods of time. Interruptions always occur, reducing the actual capacity below the theoretical field capacity. The ratio of actual or effective field capacity to theoretical field capacity is called the machineøs field efficiency.

Field efficiency is expressed as the percentage of a machineøs theoretical field capacity achieved under real conditions. It accounts for failure to utilize the full operating width of the machine and many other time delays as described in the previous chapter. Activities that occur outside the field, such as daily service, travel to and from the field, and major repairs are not included in a field efficiency measurement.

A machineøs effective field capacity can be calculated easily. After completing a field of known size, the hectares completed can be divided by the hours of actual field time to find the effective field capacity. Hectares and hours for several fields can be recorded to find the average effective field capacity for a machine

over a full season.

Average field speed can also be measured. A distance of 10 meters can be marked off in the field, placing a stake at each end. The seconds it takes to drive between the stakes must be counted. Average field speed can then be calculated with the following formula:

$$Speed(km/h) = \frac{36}{Seconds\ to\ travel\ 10\ meters}$$

[5.2]

Notes:

- The tractor takes 36 seconds to travel 10 meter at a speed of 1 km/h. That gives the constant of 36 above the line.

- If the speed increases, the seconds to travel between the stakes will decrease, for example: if the tractor takes seven seconds to travel between the stakes, the 36 is divided by 7 that gives an average field speed of 5.14 km/h.

After calculating the average field speed of the machine, the theoretical field capacity can be derived from formula [4.2], using the full width of the machine. The field efficiency can then be calculated with the following formula:

$$Field\ efficiency(\%) = \frac{Effective\ field\ capacity(ha/h) \times 100}{Theoretical\ field\ capacity(ha/h)}$$

[5.3]

If estimated field efficiency is available, effective field capacity can be calculated as follows:

$$Effective\ field\ capacity\ (ha/h) = Theoretical\ field\ capacity \times Field\ efficiency$$
$$= \frac{Width(m) \times Speed(km/h)}{10} \times \frac{Field\ efficiency(\%)}{100}$$

[5.4]

The effective field capacities in Appendix I can be used as estimates of machinery capacity under average field conditions. They were calculated from the speeds and field efficiencies listed, which were believed to be typical for

most farms.

5.6. REQUIRED FIELD DAYS

The following worksheet can be used to estimate the number of field days required for tillage, planting, and harvesting for a particular farming operation:

Column 1: List all the field operations to be done before planting. Include fall and spring tillage, application of chemicals, and sowing of small grain or forages. Do not include custom hired operations.

Column 2: List the total hectares to be covered by each operation. If some hectares have the same operation performed on them more than once, multiply the number of hectares by the times the operation has to be performed.

Column 3: List the size of the machine used for each operation.

Column 4: List the field capacity of each machine in hectares per hour. Suggestions can be found in Appendix I. It may be more convenient to skip directly to column 6 and enter the number of hectares covered per day, if this is known.

Column 5: Enter the number of labor hours available per day in the field to perform each tillage and preplant operation. Do not count time spent on repairs, transportation of machinery, livestock activities, etc. For planting and harvesting, enter the number of hours per day the planter or combine can be used.

Column 6: Multiply column 4 by column 5 to estimate the number of hectares covered per day for each operation. Decide if this is a reasonable figure based on experience.

Column 7: Estimate the number of field days needed for each operation by dividing column 2 by column 6. Find the total for each group of field operations.

An example of the worksheet is compiled in Table 5.1.

TABLE 5.1: ESTIMATION OF FIELD DAYS REQUIRED FOR FARM OPERATIONS

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7
Field operations Tractor 77 kW	**Hectares to cover**	**Machine size**	**Machine Capacity (ha/h)**	**Labor (h/day)**	**C4 x C5 (ha/day)**	**C2 / C6 days needed**
Disc	100	10'	2	10	20	5
Plow	100	4-16"	1	10	10	10
Plant	100	6-30"	2.7	10	27	3.7
Spray	100	12 row	4.8	10	48	2.1
Field Cultivator	100	21'	4.1	10	41	2.4

Use extra lines to estimate how the number of field days can be adjusted. Adjustments can be made by changing:

- The machinery size;
- The number of field operations;
- The number of hectares to be covered;
- The proportion of hectares in each crop;
- The hours available for fieldwork.

If the number of field days is still too high, they can be decreased by making use of custom hiring for some operations or by using alternative varieties of seed that is insect resistant or weed control resistant. Custom hire will increase the capacity without capital demands, while the latter will enable the farmer to cut out some mechanical operations.

5.7. AVAILABLE FIELD DAYS

The main objective of field operations is to complete certain operations within a given time frame. Failing to do so will result in an economic penalty, which farmers pay indirectly by means of timeliness cost.

Each country and each region has a unique climate, and different criteria as to what constitutes a working day. Working days available can only be expressed on a probability basis because of the randomness of the weather. Days lost due to weather will cause the timeliness cost to rise. Table 5.2 shows the effect of yield losses in Iowa (USA) caused by timeliness factors.

TABLE 5.2: PERCENTAGE LOSSES APPLIED TO CROP YIELDS AS PER DATE

PLANTING			
Corn	**% Reduction**	**Soybean**	**% Reduction**
- May 1	0.0	- May 10	0.0
- May 10	2.0	- May 20	3.0
- May 20	8.0	- May 30	7.5
- May 30	16.0	- June 9	12.5
- June 9	29.0	- June 19	25.0
- June 19	45.0	- June 29	42.5
-	-	- July 9	62.5
HARVESTING			
Corn	**% Reduction**	**Soybean**	**% Reduction**
- September 30	0.0	- October 10	0.0
- October 10	1.0	- October 20	3.0
- October 20	2.0	- October 30	9.0
- October 30	3.0	- November 9	18.0
- November 9	4.0	- November 19	30.0
- November 19	5.0	-	-
- November 29	6.0	-	-
- December 9	7.0	-	-

** Ozkan and Edwards 1984*

Table 5.2 shows that yield or quality losses in Iowa (USA) can be as high as 45% for corn and 62% for soybeans if the machinery system fails to complete the operations in time. Similar losses for other crops as well as for other countries and regions can be determined. The important factor however is that the machinery system must be able to complete the operations within the optimum time frame to prevent the increasing affect of timeliness cost. Expanding the machinery size will eliminate the timeliness cost but at the expense of fixed machinery cost. That means time and ownership cost must be balanced out to determine the most economical machinery size.

5.8. SCHEDULING FIELD OPERATIONS

The required field days under theoretical circumstances will be limited by the field days permitted by the weather and other practical factors. The adaptability of the machinery systemôs capacity and the rate of work of the operator will affect the completion of the operations before timeliness cost start to develop. The farmer will consider a number of alternative implements, calculate their capacities and select from those with sufficient capacity to do the job.

Planning field operations (described in this chapter) and matching tractors and implements (described in the previous chapter) is an interactive process. The one is dependant of the other and cannot come before the other. Further more, decisions regarding choice of machinery cannot be separated from those relating to the whole farm business planning. Availability of labor and capital affect the optimum choice. At the least, decisions regarding machinery choice and field operations involve a process of six steps, described in Figure 5.1.

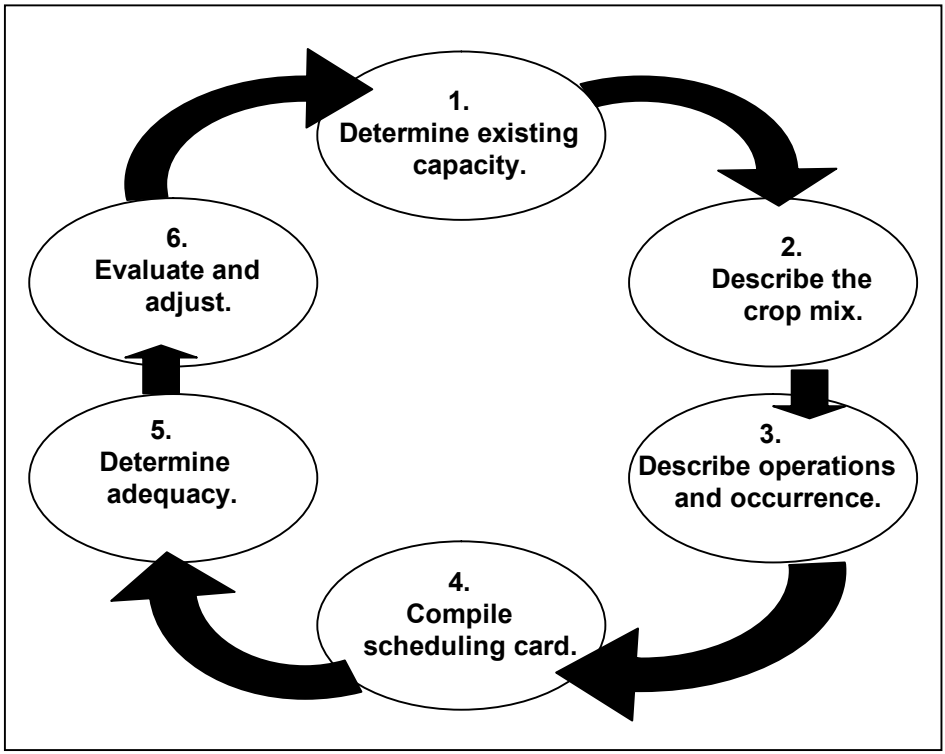

FIGURE 5.1: THE PROCESS OF SCHEDULING FIELD OPERATIONS

STEP I Determine the capacity of the existing machinery system

An example of information regarding tractors and implements are listed in Table 5.3.

TABLE 5.3: DISCRIPTION AND CAPACITY OF MACHINERY

Nr	DESCRIPTION	Size Kw, m, t	Required kW	Speed km/h	Efficiency %	Capacity ha/h
1	JD 5700 MFWD	58 kW	-	-	-	-
2	JD 6410 MFWD	77 kW	-	-	-	-
3	Claas wheat combine	3.9 m	-	4.5	74	1.3
4	Claas corn head	3.6 m	-	4.2	71	0.9
5	4 x 20" bottoms plow	2.0 m	76 kW	6.0	83	1.0
6	Offset disk	3.4 m	76 kW	8.5	79	2.3
7	One way disk	1.8 m	52 kW	6.0	79	0.9
8	9 Tine chisel plow	3.0 m	76 kW	7.5	84	1.9
9	8 Row wheat planter	3.25 m	52 kW	6.5	65	1.4
10	3 Row 3' grain drill	4.5 m	52 kW	7.5	65	2.2
11	Tecnoma 600 liter	7.0 m	52 kW	8.5	60	3.6
12	JD Cultivator	3.0 m	76 kW	8.0	84	2.0
13	Nitrogen applicator	4.0 m	52 kW	4.0	83	1.0

The information of an existing machinery system is shown in Table 5.3. The size of the listed machinery will enable the farmer to calculate the available field days. The assumption is that the farmer had already matched the implements to a tractor according to the formulas in the previous chapter.

STEP II Describe the crop mix and the working areas

The following crops are being cultivated with the existing machinery system:

- Corn 100 ha
- Wheat 200 ha

STEP III Describe the operations and the date of occurrence

The variety of field operations, the available machinery, and the date of occurrence for corn are listed in Table 5.4.

TABLE 5.4: FIELD OPERATIONS, MACHINERY TO USE, AND DATE OF OCCURRANCE FOR CORN

Operations	Begin	End	Tractor	Impl
Plow	10/10	10/11	2	5
Offset	20/9	10/10	2	6
Chisel	15/11	15/12	2	8
Drill	10/10	10/11	1	10
Spray	10/10	10/11	1	11
Applicator N	15/11	15/12	1	13
Harvest	15/6	15/7	-	4
Transport	15/6	15/7	-	-

The variety of operations for corn is listed in Table 5.4. The dates of occurrence are typical for corn production in the Free State province of South Africa and may vary for other regions and countries. The tractor and implement used for each operation are numbered according to their numbers in Table 5.3.

The variety of field operations, the available machinery, and the date of occurrence for wheat are listed in Table 5.5.

TABLE 5.5: FIELD OPERATIONS, MACHINERY TO USE, AND DATE OF OCCURANCE FOR WHEAT

Operations	Begin	End	Tractor	Impl
Plow	10/2	28/2	2	5
Offset	10/1	25/1	2	6
Offset	10/2	28/2	2	6
Plant	1/7	20/7	1	9
Spray	1/9	20/9	1	11
Cultivate	15/3	15/4	2	12
Cultivate	1/5	20/5	2	12
Cultivate	28/6	18/7	2	12
Harvest	16/12	6/1	-	3
Transport	16/12	6/1	-	-

The variety of operations and the dates of occurrence for wheat production in the Free State province of South Africa are listed in Table 5.5. Like the operations for corn, they may also vary for other regions and countries. The tractors and implements for the different operations are numbered according to their numbers in Table 5.3.

STEP IV Compile a scheduling card

A scheduling card, combining the field operations for corn and wheat described in Tables 5.4 and 5.5, are shown in Table 5.6.

TABLE 5.6: SCHEDULING CARD FOR FIELD OPERATIONS

Activities	Tempo	Rate	Total ha	Jan				Feb				Mar				Apr				May				Jun			
				Week				Week				Week				Week				Week				Week			
	ha/h	ha/day	Need	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
	(kW)	(week days)	(Possible)	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]
Plow	1.0	10	301						67	67	67																
	(76)	(6)	(420)						60	60	60																
Offset disc	2.3	10	302		100	100																					
	(76)	(6)	(690)		138	138																					
One way disc	0.9	10	201						67	67	67																
	(52)	(6)	(162)						54	54	54																
Chisel plow	1.9	10	100																								
	(76)	(6)	(456)																								
Drill	2.2	8	100																								
	(52)	(6)	(422)																								
Plant	1.4	8	301																								
	(52)	(6)	(470)																								
Spray	3.6	10	301																								
	(52)	(6)																									
Applicate N	1.0	10	100																								
	(52)	(6)	(240)																								
Cultivate	2.0	10	603											67	67	67				67	67	67					67
	(76)	(6)	(1080)											120	120	120				120	120	120					120
Harvest (Corn)	0.9	8	100																							25	25
	(76)	(6)	(173)																							43	43
Harvest (Wheat)	1.3	8	201	67																							
	(52)	(6)	(187)	62																							
Transport (Silo)																											

Activities	Jul				Aug				Sep				Oct				Nov				Dec			
	Week				Week				Week				Week				Week				Week			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]	[Possible][Need]
Plow														25	25	25	25							
														60	60	60	60							
Offset disc											34	34	34											
											138	138	138											
One way disc																								
Chisel plow																			25	25	25	25		
																			114	114	114	114		
Drill														25	25	25	25							
														106	106	106	106							
Plant	67	67	67											25	25	25	25							
	67	67	67											67	67	67	67							
Spray									67	67	67			25	25	25	25							
									216	216	216			216	216	216	216							
Applicate N																			25	25	25	25		
																			60	60	60	60		
Cultivate	67	67																						
	120	120																						
Harvest (Corn)	25	25																						
	43	43																						
Harvest (Wheat)																							67	67
																							62	62
Transport (Silo)																								

The main part of Table 5.6 shows the schedule for field operations on a weekly basis and the hectares that need to be completed for every week. The farmer himself supplies this information in the first row (black blocks) of each operation. When compiled in a computer spreadsheet, the working rate (possible hectares per week) for each operation can be calculated in the second row of each operation for a given day and week length with the existing machineryôs capacity. The information supplied in the three columns to the left of the scheduling block is used for the latter and was partly calculated in Table 5.3.

The farmer obtains a visual indication of his whole machinery process with the help of the scheduling card. He can then plan his capacity according to the timeliness factors he anticipates.

STEP V Determine the adequacy of the available capacity

With a little modification to the scheduling card, the farmer can determine if the capacity of his machinery is adequate enough to complete all the operations in the anticipated time. The modified scheduling card, determining the adequacy of the machinery capacity, is shown in Table 5.7.

TABLE 5.7: ADEQUACY OF MACHINERY CAPACITY

Activities	Tempo	Available	Adequacy	Jan				Feb				Mar			
				Week				Week				Week			
	ha/week	kW/week	kW	1	2	3	4	1	2	3	4	1	2	3	4
			(ha)	[ha][kW]	[ha][kW]	[ha][kW]	[ha][kW]	[ha][kW]	[ha][kW]	[ha][kW]	[ha][kW]	[ha][kW]	[ha][kW]	[ha][kW]	[ha][kW]
Plow	60	(76)	532						76	76	76				
			(119)						7	7	7				
Offset disc	138	(76)	380		76	76									
			(388)		38	38									
One way disc	54	(52)	156						52	52	52				
			39						13	13	13				
Chisel plow	114	(76)	304												
			(356)												
Drill	106	(52)	208												
			(322)												
Plant	67	(52)	364												
			(169)												
Spray	216	(52)	364												
			(1211)												
Applicate N	60	(52)	208												
			(140)												
Cultivate	120	(76)	684											76	76
			(477)											53	53
Harvest (Corn)	43	0	0												
			(73)												
Harvest (Wheat)	62	0	0												
			14	5											
Tractor kW needed					76	76			128	128	128			76	76
Tractor kW available		128		128	128	128	128	128	128	128	128	128	128	128	128
Tractor kW adequacy				128	52	52	128	128				128	128	52	52

Activities	Apr				May				Jun			
	Week				Week				Week			
	1	2	3	4	1	2	3	4	1	2	3	4
	[ha][kW]	[ha][kW]	[ha][kW]	[ha][kW]	[ha][kW]	[ha][kW]	[ha][kW]	[ha][kW]	[ha][kW]	[ha][kW]	[ha][kW]	[ha][kW]
Plow												
Offset disc												
One way disc												
Chisel plow												
Drill												
Plant												
Spray												
Applicate N												
Cultivate	76				76	76	76					76
	53				53	53	53					53
Harvest (Corn)												
											18	18
Harvest (Wheat)												
Tractor kW needed	76				76	76	76					76
Tractor kW available	128	128	128	128	128	128	128	128	128	128	128	128
Tractor kW adequacy	52	128	128	128	52	52	52	128	128	128	128	52

Activities	Jul				Aug				Sep			
	Week				Week				Week			
	1	2	3	4	1	2	3	4	1	2	3	4
	[ha][kW]	[ha][kW]	[ha][kW]	[ha][kW]	[ha][kW]	[ha][kW]	[ha][kW]	[ha][kW]	[ha][kW]	[ha][kW]	[ha][kW]	[ha][kW]
Plow												
Offset disc											76	76
											104	104
One way disc												
Chisel plow												
Drill												
Plant	52	52	52									
	0	0	0									
Spray									52	52	52	
									149	149	149	
Applicate N												
Cultivate	76	76										
	53	53										
Harvest (Corn)												
	18	18										
Harvest (Wheat)												
Tractor kW needed	128	128	52						52	52	128	76
Tractor kW available	128	128	128	128	128	128	128	128	128	128	128	128
Tractor kW adequacy			76	128	128	128	128	128	76	76		52

Activities	Oct				Nov				Dec			
	Week				Week				Week			
	1	2	3	4	1	2	3	4	1	2	3	4
	[ha][kW]	[ha][kW]	[ha][kW]	[ha][kW]	[ha][kW]	[ha][kW]	[ha][kW]	[ha][kW]	[ha][kW]	[ha][kW]	[ha][kW]	[ha][kW]
Plow		76	76	76	76							
		35	35	35	35							
Offset disc	76											
	104											
One way disc												
Chisel plow							76	76	76	76		
							89	89	89	89		
Drill		52	52	52	52							
		81	81	81	81							
Plant		52	52	52	52							
		42	42	42	42							
Spray		52	52	52	52							
		191	191	191	191							
Applicate N							52	52	52	52		
							35	35	35	35		
Cultivate												
Harvest (Corn)												
Harvest (Wheat)												
											5	5
Tractor kW needed	76	232	232	232	232		128	128	128	128		
Tractor kW available	128	128	128	128	128	128	128	128	128	128	128	128
Tractor kW adequacy	52	104	104	104	104	128					128	128

Table 5.7 shows the required tractor power (*kW*) in the first row of each operation and the adequacy of the implement in the second row. The tractor power is supplied in the third column from the left while the implement adequacy is calculated from the scheduling card (Table 5.6) by deducting the needed hectares from the possible hectares. The black blocks represent a surplus while the gray blocks shows a shortage. When compiled in a computer spreadsheet, the formula in the block can inform it to change color from white in the case of no value to black or gray in case of a positive or negative value.

The tractor kW adequacy for all the operations is calculated at the bottom of the table by firstly accumulating the needed kW and then deducts it from the available kW. A positive value (surplus) is once again shown as a black block while a shortage is shown as a gray block.

Table 5.7 enables the farmer to firstly determine the adequacy of the implement for each operation. Secondly, it determines the total adequacy of tractor power for all the operations. The required power for the individual operations is calculated according to the process of matching tractors and implements, described in the previous chapter.

The results of Table 5.7 can also be shown in a set of graphs. Figure 5.2 shows the adequacy of the tractor power.

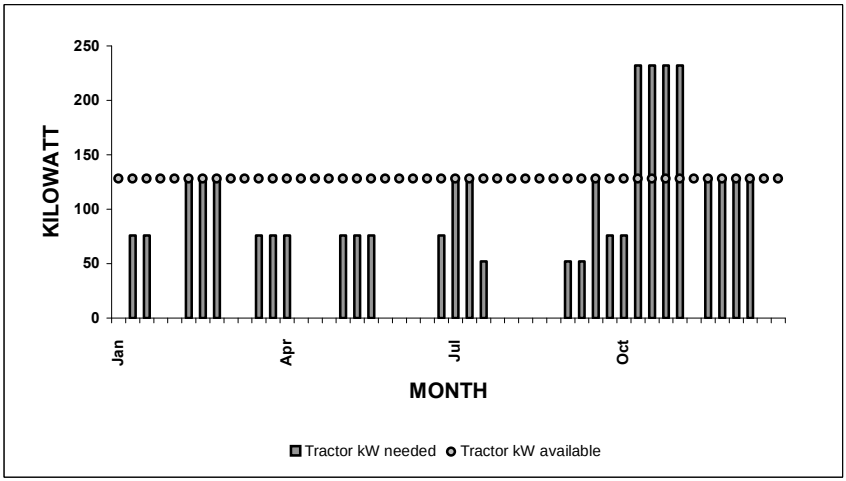

FIGURE 5.2: ADEQUACY OF TRACTOR POWER

The line of dots in Figure 5.2 shows the available tractor power. The bars represent the total needed tractor power for each week of the year. If the bars are higher than the dotted line, it means that the needed tractor power is exceeding the available tractor power.

Figure 5.3 shows the adequacy of the plowing implement.

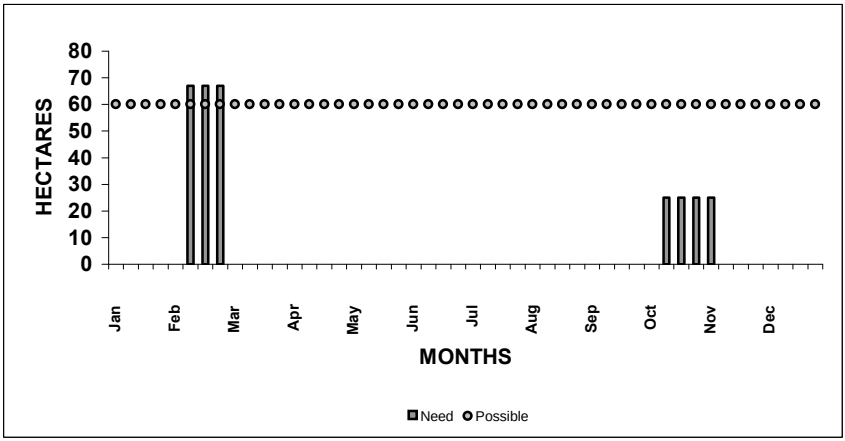

FIGURE 5.3: IMPLEMENT ADEQUACY FOR PLOWING

Once again, the line of dots in Figure 5.3 shows the available working capacity of the specific implement. The bars represent the total capacity needed for plowing for each week of the year. According to Figure 5.3, there is a shortage of capacity during February while there is a surplus during October/November.

A similar graph can be drawn for each operation. These graphs for the operations, the graph showing the tractor power adequacy, the scheduling and adequacy cards, will all together give the farmer a complete description of the occurrence and adequacy of all his field operations.

STEP VI Evaluate and adjust the planned field operations

Like any other managerial process, planning field operations will also end with an evaluation of the outcome and adjustments of the operations for even better results. The machinery system should perform the operations economically, adequately and reliably but still ensure that the crop yields and quality won't be affected by the dates of planting and harvesting. If this is not possible, either the implements or the tractor power is not adequate enough to deliver the results and would need the following adjustments:

- Custom hire or lease machines for some operations;
- Increase the size (working width) of the implements;
- Increase the tractor speed of an operation;
- Increase the efficiency of the operation by cutting out unnecessary stoppages and turns;
- Increase the working hours;
- Decrease the working area;
- Reallocate some parts of the working area to an alternative crop with different time schedules;
- Switch to an alternative tillage practice (rip instead of plow);
- Apply biotechnology to cut out certain weed or pest control operations.

Most of the above recommendations involve major changes in the machinery system. It may imply:

- Increasing ownership costs by:
    - Buying new implements;
    - Buying new tractors;
- Increasing operating cost by:
    - Using more fuel;

- Using more labor.

Evaluating the planning of field operations may mean that the adjustments must go back as far as matching tractors and implements all over again. This is definitely the case when introducing new tractors or implements to the machinery system. The cheapest alternative will be to fine-tune the existing system in order to obtain better results. Any other option will increase costs that can be hampered by limited capital resources.

After adjusting the machinery system, the whole process of planning field operations must be repeated. Once again, the new systemôs capacity must be determined, the new crop mix defined, the operations listed, the operations scheduled and the adequacy determined. Then the whole system must be re-evaluated and adjusted once again, the goal being to determine the most economical machinery system for the farm business.

5.9. CONCLUSION

When planning the field operations for a farm business, the farmer needs to know the capacity of his existing machinery system. He also needs to understand which factors influence the completion of the different operations within a given time frame. Time is of great importance as it can lead to the occurrence of timeliness factors, resulting in lower yields or decreasing quality of crops and affecting the profit of the farm business likewise.

Field operations must be scheduled to take place on a specific time within a certain time frame. The balancing act of planning field operations is therefore to make sure every operation is necessary, effective, and adding to the profit of the farm.

The field operations take place in unpredictable weather conditions. It therefore needs to be flexible and has reserve capacity in hand to cope with unforeseen circumstances. This means that the farmer must evaluate and adjust his planned field operations continuously to achieve the objective of machinery management, namely to match and schedule the machinery operations in such a way that the maximum amount of work can be achieved within the appropriate time frame so that the overall performance will return the biggest profit to the farm business.

5.10. REFERENCES

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