

## **6.1 Crop calendar, workability and labour requirements**

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### **6.1.1 Introduction**

In the preceding chapters the growth of crops was analyzed in relation to solar radiation, temperature, day length, water and nutrient availability and crop characteristics. It was shown that weather and soil conditions determine crop growth and production. So far, the human factor has not been considered. However, agriculture is distinguished from the natural situation by the intermediary role of man in the process of converting solar energy into edible energy by means of plants and animals. This involves tillage of the soil, cultivation and harvesting of crops, and care and breeding of livestock. Therefore, in addition to the growth factors discussed so far, human activity is an indispensable factor in the agricultural production process. In this section attention will be focussed on aspects of human activity in agriculture. These aspects are:

- availability of human activity
- demand for human activity
- type of human activity required
- choice between different possibilities of applying human activity.

In Chapter 1 it was emphasized that in this monograph only the technical-agricultural aspects of food production would be considered. The aspect of availability of human activity is therefore not treated, because that depends on such factors as the size of the population, its demographic composition, the level of participation, the number of working hours per day and the number of days per year available for agricultural activities. The other aspects will, however, be discussed in this section.

### **6.1.2 Crop calendar**

The demand for human activity in agriculture at a particular moment depends in the first place on the growing season, the type of crop and its development stage. The timing of the crop growing season is in most cases determined by temperature and/or water availability. At high latitudes crop cultivation during winter is impossible because of low temperatures. In regions with a distinct dry season, it is impossible to cultivate a crop during that season without irrigation. Even if temperature and soil moisture availability permit growth of certain crops, the conditions may not be suitable for all crops or crop varieties. Some crop species need higher temperatures than others, some

are more susceptible to (temporary) water stress than others and day length requirements are different among crops or cultivars. Thus, if an existing day length and temperature regime suits one cultivar of a crop species, not all cultivars of that particular crop may mature within the available growing season. Therefore, in most cases only a limited number of crops or crop varieties is suitable for a specific environment.

The demand for human activity depends further on the time required for land preparation, an activity strongly related to the physical condition of the soil, as will be discussed in Subsection 6.1.3. Before sowing or planting – an absolute prerequisite for crop growth – a suitable seedbed has to be prepared. Once the crop is seeded or planted, the length of the growing period of a given crop variety is fairly predictable, as mean temperatures at a specific site in a particular season are reasonably constant (Section 2.2). Therefore the average development rate, and thus the growth duration of that crop, will be approximately the same each year if the start of the growing period has not been delayed too much because of, say, unusual weather conditions.

During the growing period of a crop, the farmer has to perform a number of field operations to create or maintain the most favourable conditions for crop growth. Among these are the reduction of competition by unwanted plants (by destroying them), optimizing the availability of nutrients and water (by fertilizer application, drainage and irrigation), and protection of the crop (by pest and disease control). At crop maturity, harvesting is necessary. Some on – farm processing may also take place and the products are stored or marketed. Most of these activities have to be carried out in a given order and each of them within a limited time span. Therefore a crop activity calendar can be constructed, indicating the most favourable timing of the various activities and the type of operations required. Such crop activity calendars are elaborated for rice, maize and cassava in Subsection 6.1.5.

### *6.1.3 Workability*

Workability expresses the possibility to perform a certain activity in a given environment. Whether a situation is workable depends on the availability of labour, farm equipment and required materials, the state of the crop, weather conditions and state of the soil, and type and nature of the field operation. In this subsection attention is focussed on the relation between the state of the soil and workability. In general, a soil is considered tractable, that is suitable to be worked, if a tractor or any other required farm machine can move on that soil and satisfactorily perform its function without causing temporary or lasting damage to the soil. The most common form of damage is soil compaction. That is basically a reduction in volume of a given mass of soil. It may be expressed as a change in bulk density or porosity (Section 3.2). Many of the soil physical properties, such as hydraulic conductivity and soil moisture characteristics are affected by bulk density. If bulk density becomes too high,

resulting in insufficient air space in the soil, plant – root development may be hampered, which will conceivably lead to a reduction in crop yield. The degree of soil compaction is, among other factors, determined by the pressure applied by the machine and the soil – moisture content at the time of the operation. The pressure applied by the machine is a function of the weight of the farm equipment and the contact area between the equipment and the soil. The soil – moisture content at a given moment depends on the water balance of the root zone (Section 3.2).

The limiting upper soil – moisture content for satisfactorily performing a field operation by hand labour is, rather arbitrarily, set at a soil – moisture suction of 10 cm, i.e. nearly saturated. For operations using draught animals it is set at 100 cm, i.e. near field capacity. For operations using power equipment it is set at 500 cm. These limits do not apply to the cultivation of banded rice, as special equipment is required for wet – land preparation and an important aim of land preparation for that crop is the creation of a compacted subsurface layer to minimize drainage. Land preparation at the end of a dry season, may, especially on heavy soils, be hampered by a low soil – moisture content. In that case workability is limited, especially if the work has to be carried out completely by hand or with animal traction, because the soil is so hard that cultivation requires too much force. In the present approach, the soil is considered workable if, after a long dry period, at least 75 mm of rain have fallen in the last 20 days before the actual operation has to be carried out.

#### *6.1.4 Labour requirements*

Information on the time spent on different agricultural operations is generally more readily available and more accurate for mechanized operations than for systems where manual labour or animal traction are employed. Preferably, labour requirements are defined as the time required to carry out a well – defined operation, under standard conditions, by a skilled healthy labourer, working at normal pace, using standard equipment and at maximum efficiency. This time requirement includes, apart from the actual operation:

- the time required for actions necessary for smooth continuation of the job, e.g. operating the filling mechanism of a sowing machine
- the time required to repair minor breakdowns
- the time required to install the implements, to move them between farm buildings and field, and to perform the necessary maintenance.

The total set of activities required in the agricultural production process can be classified on the basis of timing of the major operations involved:

- preparatory activities, such as land preparation and preparation of plant material
- planting or seeding

- crop management, such as application of fertilizer, irrigation, thinning, topping, weed control and pest and disease control
- harvesting
- on – farm processing.

Most of the operations can be executed in various ways, distinguished mainly according to the source of energy used:

- complete manual labour
- use of draught animals
- light or heavy mechanical equipment using fossil energy.

The time required for any operation is expressed in man – hours per hectare or in some cases in man – hours per unit product weight. In the analysis, this definition may lead to certain difficulties. For some operations, the physical constitution may influence the operation time, so that working hours of children, women or aged people cannot be counted indiscriminately, but have to be weighed for conversion to standard man – hours. In other cases however, it is not physical strength, but acquired skill that is of importance. Farringtons (1975) data suggest that the application of weighting factors depending on age and sex, irrespective of the activities, results in underestimation of labour time, while indiscriminate use of actual working hours results in overestimation. As there is no general agreement on the value of the weighting factors, and assuming that activities requiring more physical effort are mainly carried out by men, preference is given to an indiscriminate use of actual working hours, unadjusted for sex or age.

As the time requirement for manual product handling varies with the quantity of the product, the time required for these activities is expressed in man-hours per unit weight. When machines or draught animals are used, the labour requirement will in general be independent of the quantity of the product, hence for these operations time is expressed in man – hours per unit area.

Labour requirement data for operations carried out manually or with draught animals are scarce. Most of that type of information originates from socio – economic surveys and case studies, in which the time spent on agricultural activities is but one of the aspects treated. In many of these studies, working conditions are described in a rather rudimentary way, the operations are ill – defined from an agro – technical point of view and, consequently, the data are not very accurate. The labour requirement estimates for the various agricultural operations (Tables 61 – 68), are based on a literature survey by Van Heemst et al. (1981). A major part of these data is derived from the type of studies indicated above and they show, therefore, large variations. If actual labour requirements are available for a specific region, use of these data is preferable to the broad averages presented in this section.

Table 61. Labour requirement estimates for land preparation (h ha<sup>-1</sup>).

Activity	Manual	Draught animal	Power equipment	
			light	heavy
ploughing, per operation		28	17	6
hilling up, per operation	85	9	9	7
harrowing, per operation		24	10	3
puddling, per operation		29	13	7
levelling, per operation		34	4	3
bunding plus plastering	20			
digging by hoe	300			
spading, 20-25 cm	500			

Table 62. Labour requirement estimates for the pre-treatment of plant material (h ha<sup>-1</sup>)

Activity	Manual	Mechanical
rice, nursery preparation	80	
preparation of cuttings		
for sweet potato	75	
for cassava	25	7
shelling groundnut	55	1

Table 63. Labour requirement estimates for sowing or planting (h ha<sup>-1</sup>).

Activity	Manual	Draught animal	Power equipment
rice, transplanting	280		40
rice, seeding	95	15	10
maize	80	15	10
sorghum	80	15	10
millet	80	15	10
cotton	55	15	10
groundnut	85	15	10
soya bean	85	15	10
mung bean	85	15	10
cassava	70		5
sweet potato	70		5
potato	75		
yam	75		
sugarcane	230		5
kenaf	50		
jute	50		
tobacco, transplanting	240		

Table 64. Labour requirement estimates for broadcast fertilizer application (h ha<sup>-1</sup>).

Activity	Manual	Draught animal	Power equipment
fertilizer application	3	2	1

Table 65. Labour requirement estimates for weed control (h ha<sup>-1</sup>).

Activity	Manual	Draught animal	Power equipment
first weeding	145		
second weeding	120		
third weeding	65		
fourth weeding	20		
mechanical weeder		7	2-16
sprayer	25	2	1-4
thinning	60		
topping	40		
desuckering	40		

Table 66. Labour requirement estimates for crop protection against seed predation by birds (h ha<sup>-1</sup>).

Crop	Manual
rice	126
maize	55
sorghum	320
millet	320
groundnut (monkey)	20

Table 67. Labour requirement estimates for harvesting activities

Activity	Manual (h t <sup>-1</sup> )	Draught animal (h ha <sup>-1</sup> )	Power equipment (h ha <sup>-1</sup> )
all harvest activities excluding transport:			
rice	95	40	13
wheat			
cutting	12	5-8	
binding	8-12		
binder		9-16	8-16
making sheaves	3-6		

Table 67. (continued)

Activity	Manual (h t <sup>-1</sup> )	Draught animal (h ha <sup>-1</sup> )	Power equipment (h ha <sup>-1</sup> )
combine			2-10
maize	110		5
sorghum	210		
millet	210		
cotton	620		10
groundnut	195	35	22
soya bean	100		
mung bean (three pickings)	550		
cassava	12	100	30
sweet potato	25		100
potato	5	7	18-68
sugar cane	13		
kenaf	90		
jute	90		
tobacco	800		
transport from field to farm:			
rice	42	30	
wheat		28-30	
maize	42	30	
cassava	16		
sugar cane	8		
stalk disposal:			
cotton	40		2

Table 68. Labour requirement estimates for on-farm processing.

Activity	Manual (h t <sup>-1</sup> )	Draught animal (h ha <sup>-1</sup> )	Power equipment (h ha <sup>-1</sup> )
threshing:			
rice	70 (flair)	190	10
wheat	80		11-25
maize	42		
sorghum	75		
millet	75		
soya bean	200		
mung bean	80		

Table 68. (continued)

Activity	Manual (h t <sup>-1</sup> )	Draught animal (h ha <sup>-1</sup> )	Power equipment (h ha <sup>-1</sup> )
winnowing: rice	1-5		
picking: groundnut	185		
shelling: groundnut	165		
grading, baling: cotton	570		
tobacco	1000		
retting: kenaf	80		
jute	80		
cleaning, drying: kenaf	350		
jute	350		
stringing, airing, curing: tobacco	500 (sun curing)		
tobacco	800 (flue curing)		

### 6.1.5 *The choice between alternative applications of human activity*

In general, a farmer cultivates more than one crop during the cropping season, to spread risks or to satisfy his subsistence needs. In such a situation, the farmer may have to perform various operations at the same moment, e.g. land preparation for one crop and controlling weeds in another. If insufficient labour is available to carry out both jobs at the same time, a choice has to be made between the two activities: either to abandon cultivation of one crop, with the consequence of no yield at all, or to be content with a lower yield of the other crop because of weed competition. Especially farmers who perform their field operations completely by hand or with animal traction are confronted with this problem of timeliness; they are often forced to minimize the care given to their crops, which results in reduced yields. But also in mechanized systems of agriculture, farmers are confronted with the problem of timeliness. For maximum benefit, all agricultural operations have to be carried out at the

very moment they are needed. Working conditions such as the weather, or the state of the soil, or unavailability of labour or equipment, may force a deferment of the required operation, which always results in a yield reduction.

To avoid as much as possible interference between various agricultural activities, a farmer makes his choice among the different crops suited to the specific environment, to obtain a crop mix that meets his labour availability in the course of time. This is done by determining for each crop a crop activity calendar, and calculating the labour demand for each period of the year. Then the cropping pattern is chosen for which the labour demand is distributed as evenly as possible over the year. In no case may labour peaks occur to such an extent that certain operations are impossible. This procedure is explained in more detail in Section 6.2.

#### 6.1.6 *Crop activity calendar and labour requirements for transplanted rice, maize and cassava in northeastern Thailand*

For this example, a location was chosen in northeastern Thailand, near Udon Thani (17°23'N, 102°48'E), for which average monthly precipitation and potential evapotranspiration are shown in Table 69.

At some time in April, the threshold of 75 mm of rainfall in 20 days is exceeded, hence land preparation for upland crops may start at the end of April or the beginning of May. As the soils in this area are rather sandy, land preparation for cassava may start even somewhat earlier, so that cassava planting can begin early in the wet season. For banded rice, land preparation can only take place with water standing on the field. Therefore it can start

Table 69. Average monthly precipitation (mm) and potential evapotranspiration (mm) in Udon Thani (17° 23'N, 102° 48'E), northeastern Thailand.

Month	Precipitation	Potential evapotranspiration
January	8	105
February	21	120
March	41	162
April	75	172
May	219	156
June	252	139
July	224	142
August	293	133
September	293	129
October	85	135
November	8	112
December	2	98

only from the moment that precipitation exceeds potential evapotranspiration, towards the end of May.

Land preparation for rice, maize and cassava includes ploughing with a draught animal and an indigenous wooden plough, followed by harrowing once. For maize and cassava the seedbed is ready after these operations. For banded rice, land preparation is continued by puddling, levelling and preparation or maintenance of the bunds.

Maize is seeded. Cassava is propagated by stem cuttings, which are planted in parallel rows, 1 – 1.5 m apart, with spacing within the row of 0.8 – 1.5 m, depending on the cultivar and local tradition. For banded rice, seedlings are raised on a nursery bed and transplanted in the field when 5 – 10 weeks old, depending on field conditions. About 0.1 ha nursery bed is required to provide seedlings for one hectare of paddy field. Fertilizers may be applied at seeding or planting as a basal dressing, sometimes followed by a top dressing six weeks later.

Weeds compete with crop plants for essential growth factors, such as energy, nutrients and soil – moisture, which affects crop growth unfavourably and may result in reduced crop yields. The effects of weed competition are most detrimental during the early stages of growth, before a closed crop canopy is formed. At that time essential nutrients are irreversibly incorporated in the weeds, while the crop does not yet intercept sufficient light to prevent weed growth. This critical period lasts for cassava for about three months after planting, and for maize and rice approximately until development stage 0.4 (for more details, see Section 6.3). The duration of the pre-flowering phase is about 85 days for rice, and 75 days for maize for the varieties used at this location, hence the rice crop has to be kept weed – free for the first 34 days after transplanting, and the maize crop for the first 30 days after emergence. For rice, a biocide may be applied at heading to protect the crop against pests and diseases. During the last part of the seed filling period, rice and maize must be protected against seed predation by birds. Bird scaring is generally a child's job.

Finally, at maturity the crops are harvested. The growing season ends for upland crops at the end of September or the beginning of October, the end of the rainy season. For banded rice, growing on heavier soils with a larger store of available water, the growing season may extend another month.

If it is assumed that all land – preparation operations are performed with animal traction and all other operations with hand labour, crop activity calendars can be constructed for the three relevant crops. For banded rice, land – preparation activities can start only after the fields are flooded. At the end of May, rainfall exceeds potential evaporation, and water accumulates on the field. Preparations for the nursery bed start in the first ten – day period of June. The soil is ploughed twice, harrowed, puddled and levelled to prepare the seedbed before broadcast seeding. During growth of the seedlings, water supply must be assured, if necessary by lifting water onto the seedbed. After

installation of the nursery bed, land – preparation for the paddy field starts in the last ten – day period of June by a first ploughing, followed by a second ploughing plus harrowing in the first ten – day period of July. In the second ten – day period of July the field is puddled, levelled and banded. Transplanting starts in the last ten – day period of July, the seedlings being about 5 – 6 weeks old. At transplanting, fertilizer is applied broadcast, and the operations are completed during the first ten – day period of August. A top dressing of fertilizer is applied at the maximum tillering stage of the rice crop in the second ten – day period of September. At heading, in the first ten – day period of October, a biocide is applied. Bird scaring is necessary during the last ten – day period of October and the first ten – day period of November. The crop is harvested from the second ten – day period of November onwards. The labour profile of all activities with their labour requirements is shown in Table 70, the appropriate labour times being taken from Tables 61 – 68.

For activities associated with the nursery bed, one overall value is given, including all necessary operations. The harvesting operation is sub – divided into cutting, transport from field to farm compound and threshing. The la-

Table 70. Possible crop activity calendar for transplanted rice, northeastern Thailand.

Date	Activity	Labour (h ha <sup>-1</sup> )	
		Field	Nursery
1-10 June	start nursery preparations		
10-20 June	nursery		
20-30 June	nursery; first ploughing of field	28	80
1-10 July	nursery; second ploughing and harrowing of field	52	
10-20 July	nursery; puddling, levelling, bunding, plastering field	83	
20-31 July	transplanting	280	
1-10 August	fertilizer application	3	
10-20 August	weed control	145	
20-31 August			
1-10 Sept.	fertilizer topdressing	3	
10-30 Sept.			
1-10 Oct.	biocide application	25	
10-20 Oct.			
20-31 Oct.	bird scaring	63	
1-10 Nov.	bird scaring	63	
10-20 Nov.	cutting (sickle)	238 <sup>a</sup>	
	transport	105 <sup>a</sup>	
	threshing	175 <sup>a</sup>	

<sup>a</sup> Assumed yield 2500 kg ha<sup>-1</sup>. Land preparation by animal traction, other operations by manual labour, bird scaring by children.

bour requirements for harvesting activities are expressed per unit weight, thus the time requirement per hectare can only be calculated if the yield is known. For the case presented in Table 70, a grain yield of 2500 kg ha<sup>-1</sup> may be assumed.

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### **Exercise 79**

Construct crop–activity calendars for maize and cassava grown at Udon Thani. Land preparation activities are carried out by animal traction. Unless specified otherwise, all other activities are performed by manual labour.

Land preparation for both crops requires ploughing twice and harrowing once. Fertilizer is applied at sowing or planting only.

For maize, start land–preparation in the second ten–day period of May. Hand weeding is done once, one month after sowing. Assume a total growing period of 110 days and a grain yield of 3000 kg ha<sup>-1</sup>.

For cassava, start land preparation in the first ten–day period of April. Mechanical weeding is done once, 20 days after planting, manual weeding is done once, 20 days later, and hilling up is carried out once, 30 days after the manual weeding. Start harvesting the cassava in the first ten–day period of November, assuming a yield of 15 t ha<sup>-1</sup> of fresh roots.

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### **Exercise 80**

Calculate for each of the three crops, cultivated according to Table 70 and Exercise 79, the total number of labour hours per hectare.

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