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COMPUTATION OF PERIODS OF WORKABILITY IN THE PENGKO PLAIN IN SUDAN DURING 40 YEARS BY THE ANALOG MODEL ELAN

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1. INTRODUCTION

Euroconsult b.v. is making a study of the possibilities for reclamation of the Pengko Plain in Southern Sudan in order to increase food production in this African country. One of the problems in this is that the periods with soil in will workable condition are very short. Mostly the soil is either too dry or too wet for tillage operations.

The analog model ELAN can calculate moisture conditions in the soil from meteorologic data. As it is a very fast model (time scale about 2 minutes per year) it is possible to compute workability periods over a large number of years. With this output as datum a frequency analysis can be made of the occurrence and length of workable periods.

1.1. C l i m a t e a n d w h e a t h e r

Sudan has a dry season from December to April in which few rainfall occurs and a wet season from May to November with about 1000 mm precipitation. This rain is falling in large but also in low quantities varying roughly from 1 to 100 mm.day^{-1}. Potential evaporation (0.8 E_o) varies from 2 to 10 mm.day^{-1}, the larger values mostly in the dry season.

Daily data of precipitation and evaporation (Piche) are available from 1941 to 1980. In September 1980 evaporation data lacked, averages of other years have been used. Many data of 1973 were not present; so this year was omitted.

1.2. S o i l

The soil is a heavy clay fairly uniform to about 1 m depth. A number of 4 soil samples was provided by Euroconsult, 2 of the top 20 cm and 2 from a depth about 70 cm. The top soil samples contained some sand irregularly distributed and many hollows. They could not be used for determination of moisture characteristic and conductivity because of their lack of uniformity. From one of the deeper samples these soil physical properties could be determined; the second samples data got lost by mal functioning of the instruments used.

The moisture characteristic is given in Fig. 1. The unsaturated conductivity relation which holds for this sample is:

$$K \hat{=} 0{,}5\ e^{0.023\Psi}$$

here in is K conductivity in $cm.day^{-1}$

Ψ soil moisture suction in cm (negative in unsaturated state

1.3. M o d e l 'E L A N'

For a full description of the electronic analog model see WIND (1979). This model gives the possibility to calculate moisture contents in the unsaturated zone of the soil, drain outflow, surface runoff, depth of groundwater table and actual evaporation. These output data are computed from daily precipitation and potential evaporation data as input. The analog model is connected to a PDP-computer; this brings the input data into the model and the model's output is recorded in the computers memory.

ELAN has normally a time scale of 1:43,200, which means that one real day is simulated in 2 seconds. For this investigation the time scale has been decreased by a factor 5 in order to simulate 40 years in fairly short time.

The model variables have to be adjusted so that they are in agreement with

- moisture retention curve of the soil
- relation between moisture suction and conductivity

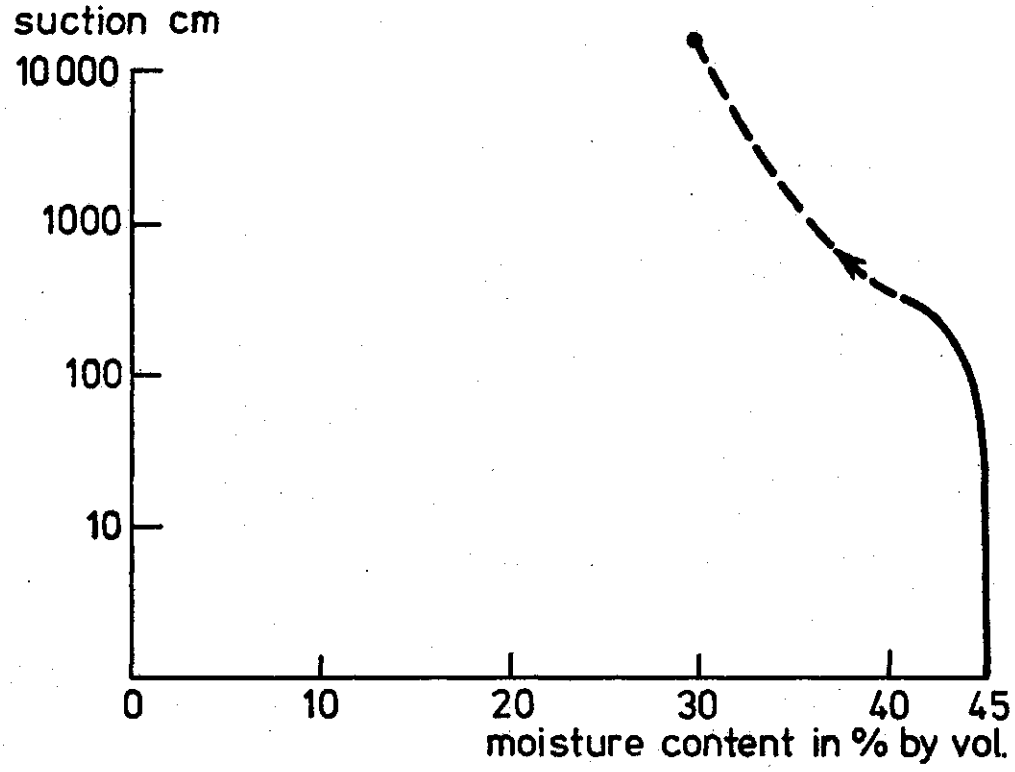

Fig. 1. Moisture characteristic of the sample of 70 cm depth. The point at 16,000 cm and the full line have been determined. The ipper workability limit of 43.5% is according with a moisture suction of 200 cm

- drain depth
- drain intensity
- reduction of actual evaporation independance of moisture content
- ponding depth above which surface runoff occurs

Before a simulation-run can be made a certain initial condition has to be adjusted.

1.4. F i e l d o b s e r v a t i o n s

During 1979 and 1980 observations have been made of moisture content at different places and depth. Every day a judgement has been made in the field whether the soil was workable or not.

2. PROCEDURE

The soil data mentioned in 1.2 are brought into the model ELAN. Than the moisture content of the top soil is computed day by day over the period of field observations. As input data, precipitation and evaporation, readings are used which have been made on the experimental plot where also the field observations of soil moisture have been made.

Simulated and observed moisture contents are compared. If they do not agree sufficiently the soil data can be changed slightly and other simulation-runs are made until sufficient agreement between simulated and observed data has been reached.

Workability limits are derived from the simulated moisture data in workable and non-workable periods.

Simulation-runs are made for the years between 1941 and 1980. The course of moisture contents in the top soil is recorded day by day. The length of workable and non-workable periods are read from this records in decades starting March 1.

3. EXECUTION

The procedure could not be followed completely because some data lacked. This concerns the soil moisture determinations. Table 1 gives a review of the observed moisture contents in workable and non-workable condition.

Table 1. Moisture contents (% by weight) observed at the pilot farm in the top layer

Field	Non-workable	Workable
C_2B	10.1	
III 6	11.4	11.5
D 2	12.4	8.5
IV 2		8.2
III 5	14.4	
D 1	12.0	
D 6	12.3	
IV 11		9.6
III 5	12.7	

Even in conditions too wet for field operations these moisture contents are very low when compared with the moisture characteristic (Fig. 1). The moisture content at wilting point is even more, 19.5% by weight. So either the moisture characteristic or the field data are incorrect. As the simulation is only possible with the use of a moisture characteristic and there is no opportunity to make a new one, we assume that the moisture characteristic is correct. By this assumption the field moisture data are rejected; it is not likely that such a heavy soil has such low moisture contents in wet periods.

This causes that no check can be made on the moisture characteristic and also not on the moisture - conductivity relation.

For the check on the initial condition, the reduction of actual evaporation and maximum ponding depth the observations of workability

condition have been used, as far as possible.

3.1. Initial condition

The question which initial condition has to be used every year in the simulation of 40 years is fairly difficult. If there is no irrigation between November and April, it is clear that the soil will be very dry at the beginning of the wet season. This situation exists now a days. But as it is intended to grow irrigated rice in the dry season the soil can be much wetter in April than it is now. This will depend on the date and quantity of the last irrigation before harvest.

That the initial condition at April 1 has large influence on workability in May 1980 is shown in Fig. 2. The first date with too wet conditions for tillage is varying from April 16 to May 29. After that date the influence of initial condition is neglegible.

The number of workable days in April and May is strongly dependent on the initial condition chosen. For the 40 years simulation it has been assumed that at March 1 the moisture content of the whole soil was saturated minus 10 mm. In autumn the initial condition chosen in spring has no influence on the simulation result.

3.2. Reduction of evaporation

The evaporation of bare soil is mostly considerably smaller than potential evaporation. A dry top layer reduces the liquid- and vapor flux from soil to atmosphere. Only in very moist condition of the top soil actual evaporation equals potential evaporation.

In the model ELAN there is a factor b/α which reduces actual evaporation proportional with the moisture suction of the top soil. The correct value of this factor can be found from comparison of observed and simulated moisture contents. As good observations of soil moisture are lacking the check had to be made with the aid of workability data. The most critical period is the first half of August 1980 when conditions too wet for tillage have been observed. Fig. 3 shows that b/α values of less that 23 lead to fairly dry conditions in that period. High b/α values cause such low evaporation that loss of moisture hardly occurs.

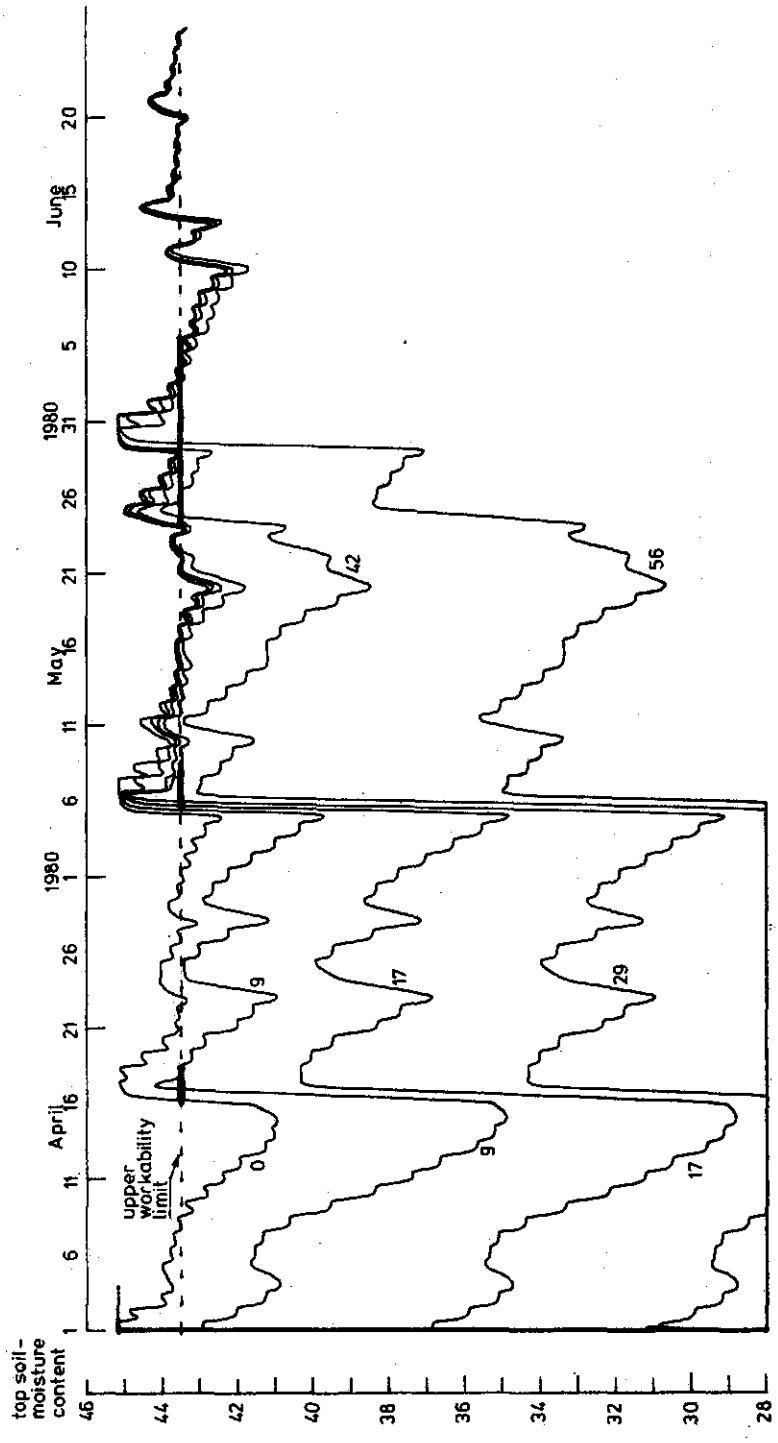

Fig. 2. The effect of initial condition on the moisture contents simulated in the spring of 1980. The figures give the lack of moisture compared with total saturation at April 1. The horizontal dotted line at 43.5% is the upper workability limit. The full parts on this line refer to non-workable conditions observed in the field

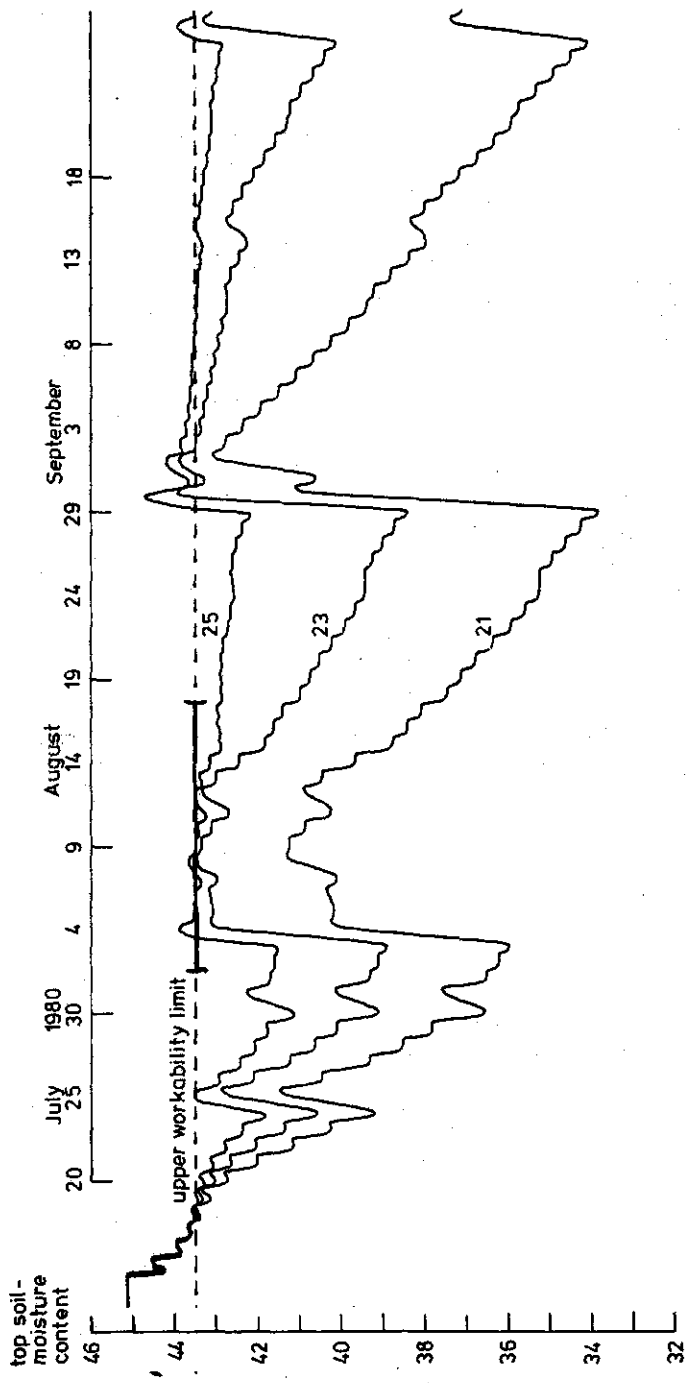

Fig. 3. The effect of reduction of evaporation in dependance of moisture suction. The figures are giving model-coefficients for the relation between actual evaporation and moisture suction

Therefore $b/\alpha = 23$ has been chosen for the 40 years simulation.

3.3. Maximum ponding depth

When precipitation intensity is larger than the infiltration capacity of the soil ponding of the surface occurs. This ponding water has to infiltrate afterwards or to run off over the surface. Runoff will only occur if a certain maximal ponding depth has been exceeded. This maximal ponding depth can be chosen in the model; because of the reduced time scale only in multiples of 5 mm. When the integrated amounts of precipitation minus infiltration exceeds the maximal depth the excess of water is removed from the system at once.

According to Fig. 4 the choice of this maximal ponding depth seems to be fairly irrelevant. This is caused by the fact that actual evaporation in wet condition is larger than in dry. If a crop was present, which transpires water extracted by roots from deeper layers the reduction of evaporation would be smaller. Then the effect of maximal ponding depth should be larger.

The maximal ponding depth in the 40 years simulation has been chosen at 5 mm.

3.4. Sub-surface drainage

It has been assumed that no sub-surface drainage was present. In the model this is interpreted by a drainage module with intensity zero below the soil profile of 140 cm depth.

The presence of a sub-surface drainage of reasonal intensity has some favourable effects on the number of workable days.

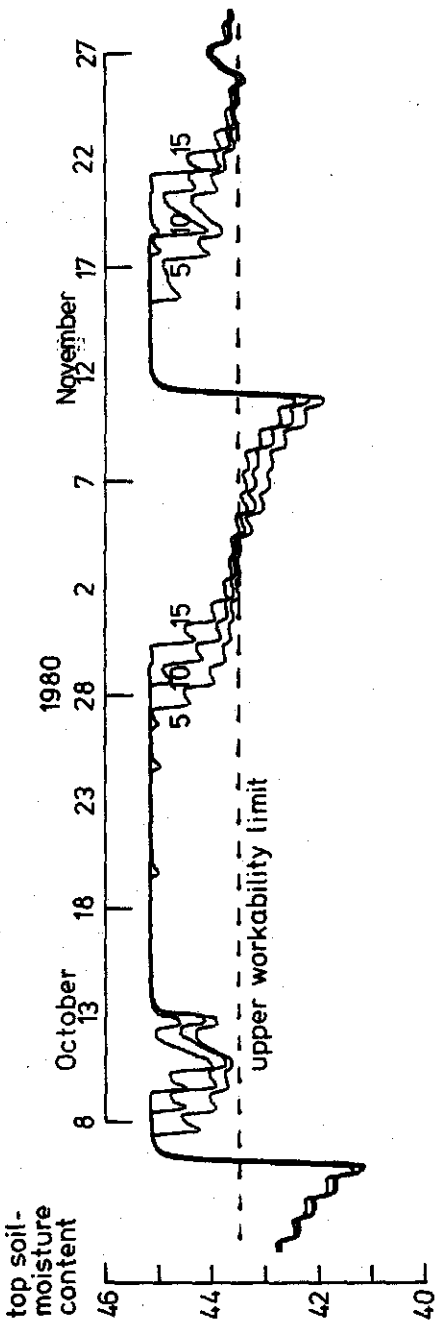

Fig. 4. The effect of the maximum value of ponding depth. Surface runoff occurs when more than 5, 10 or 15 mm water is present on the surface

4. WORKABILITY LIMITS

The workability judgements made in the field in 1980 were compared with the moisture contents simulated by ELAN.

The moisture contents of the first workable day after a non-workable period are listed in Table 2. From this it is clear that the workability datum in August differs much from all the other data.

Table 2. Moisture contents at the beginning of workable periods in 1980

Date	Moisture content
June 7	43.2
June 16	43.7
June 22	43.8
August 18	41.6
September 9	43.1
Oktober 1	43.3
November 1	43.5
November 21	43.6
November 31	43.5
Average all data	43.3 ± 0.67
Average except August	43.5 ± 0.25

There is very low probability that a value of 41.6 belongs to a population with an average of 43.5 if the standard deviation is 0.25. Therefore the moisture content of 43.5% by volume has been chosen as upper workability limit.

For the lower workability limit, between good and too dry, there were no data available. As has been told that after a dry period workability did begin when about 50 mm rain had been fallen it was concluded that this limit is not very low. The value of 38.5% has been chosen. Although this choice is arbitrary its influence is only small. In summer this value seldom occurs. At the beginning and end of the dry period the moisture changes are so fast that the limit of

38.5% is passed only a few days earlier or later than a large range of other values.

5. RESULTS

The results of 39 years simulation are given in Tables 3, 4 and 5. Table 3 gives the number of workable days per period of 10 days, beginning at March 1. The first and mostly the second decade of March should not be taken into consideration because these are unreliable due to the arbitrary initial condition. Table 4 and 5 give the number of non workable days because the soil is too wet or too dry. It seems that the wheather in the last 7 years has been more regular than before, In these last years the dry season ended between half April and half May. There are other years in which the wet season only started in June (53, 58, 67) or even July (61, 72). But there are also years with moist soil already in March (48, 57, 66, 69, 70).
The beginning of the dry season can fall end December but also beginning of November.

The test year 1980 had more workable days than any of the other years, about twice the average. This was caused by a very low number of too wet days and there were also few days too dry. The test year 1979 was more close to normal. In that year there were only few transitions from non-workable to workable conditions.

The data of workability have been grouped together to month's and combinations of month's in Table 6 and 7 for spring and autumn. The spring period is April, May and the first half of June. Some years have zero workable days even in the whole period of 2½ month. These are the years 58, 61, 67 and 72; the lack of workability is caused by a too late start of the rainy season. In other years very low workability is caused by combination of both too wet and too dry conditions (42, 46, 75 and 79).

This means that in 20% of the years there are less than 4 workable days in spring. The workability can possibly be increased by irrigation because drought is more often reason for lack of workability than is water logging.

In autumn the workability is better than in spring; however, also one year (67) had no workable days in September and October. This was caused by too wet conditions. Also some other years lacked workability because of too much rain. Too dry conditions did hardly occur

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*** SUDAN *** NUMBER OF WORKABLE DAYS PER DECADE THE FIRST DECADE STARTS AT THE 1ST OF MARCH.

YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	SUM	YEAR
1941	4.8	1.6	0.0	0.0	0.0	0.0	0.0	0.0	5.8	1.0	0.0	0.2	0.6	0.0	5.0	1.6	7.4	0.0	0.0	0.4	0.0	7.0	6.0	4.4	8.2	0.6	7.6	10.0	1.6	0.0	73.2	1941
1942	4.2	6.0	5.4	0.0	0.0	0.0	0.0	2.4	0.2	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	1.6	4.8	8.8	9.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0	45.4	1942
1943	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	5.8	2.6	0.0	0.0	1.2	9.0	4.0	0.0	0.4	0.0	1.4	9.8	4.0	8.4	4.8	0.0	0.0	0.0	0.0	0.0	56.0	1943
1944	3.9	0.0	0.0	0.0	0.0	0.0	2.6	5.0	1.4	3.8	1.0	1.8	1.4	0.0	0.0	0.0	0.2	0.6	0.2	0.0	0.0	0.6	6.2	2.4	7.2	5.8	8.0	4.6	0.0	0.0	56.6	1944
1945	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.6	1.2	0.0	0.0	0.0	1.4	0.4	0.0	3.6	0.0	0.0	0.0	4.4	2.0	6.0	0.2	2.4	10.0	3.6	6.4	7.6	0.0	58.4	1945
1946	4.6	0.0	0.0	0.0	0.0	0.2	0.6	1.0	0.0	0.0	0.0	0.6	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	2.2	0.0	0.2	6.6	0.6	8.6	9.6	0.0	0.0	35.8	1946
1947	4.6	0.0	0.0	1.6	8.8	9.2	4.4	0.6	0.6	0.0	0.6	1.4	0.2	0.0	0.0	0.4	2.6	0.0	0.0	0.0	0.6	0.4	4.2	10.0	3.6	0.0	0.0	0.0	0.0	0.0	53.8	1947
1948	5.6	5.0	4.6	4.4	6.6	2.6	2.4	0.8	7.0	6.6	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.2	4.4	9.4	9.2	1.8	10.0	1.6	0.0	0.0	0.0	83.0	1948
1949	3.6	0.0	0.0	0.0	0.0	0.0	0.0	5.2	2.0	0.2	2.0	5.4	4.4	0.0	0.0	0.0	1.8	0.2	0.2	0.0	3.6	1.8	5.8	1.6	9.8	1.6	0.0	0.0	0.0	0.0	49.2	1949
1950	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.6	2.2	1.6	1.2	3.0	3.2	0.0	0.0	0.0	2.6	0.2	5.4	1.0	0.0	2.0	2.4	3.8	9.8	0.4	0.0	0.0	0.0	50.6	1950
1951	2.8	0.6	0.0	0.0	0.0	0.0	0.0	4.6	3.0	0.6	1.2	4.2	10.0	5.0	0.6	0.0	0.4	2.4	8.4	7.6	0.0	0.2	1.8	0.0	2.6	0.2	6.0	7.8	0.0	0.0	70.0	1951
1952	2.8	0.0	0.0	0.0	0.0	0.0	0.0	3.8	9.2	1.4	1.4	1.0	1.2	1.4	2.8	0.0	0.0	0.0	3.0	1.8	0.6	0.8	4.2	0.2	7.4	4.6	6.0	7.6	0.0	0.0	61.2	1952
1953	6.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.6	4.2	0.8	0.0	1.8	0.0	0.0	1.4	9.8	9.0	5.8	7.6	1.0	2.0	7.0	5.0	8.6	0.0	0.0	0.0	78.2	1953
1954	2.6	0.0	0.0	0.0	0.0	0.0	0.0	1.0	8.8	1.8	1.2	1.0	0.0	1.2	0.0	0.6	1.6	1.4	0.0	0.0	2.4	0.2	2.8	5.2	1.4	8.8	1.0	0.0	0.0	0.0	43.0	1954
1955	3.0	0.0	0.0	0.0	3.6	6.4	5.4	0.4	7.2	9.4	10.0	0.6	3.4	5.6	2.8	2.0	0.0	0.8	0.0	0.0	0.0	0.0	6.2	9.8	4.0	3.8	10.0	1.8	0.0	0.0	96.2	1955
1956	7.6	0.0	0.0	0.0	0.0	3.0	8.6	2.4	1.0	1.4	3.6	7.0	0.0	4.6	0.6	0.2	0.0	0.4	3.6	1.6	5.6	1.0	0.2	3.6	5.0	7.0	7.6	0.6	0.0	0.0	76.2	1956
1957	5.0	8.2	8.8	2.4	7.6	6.4	10.0	8.4	3.2	0.0	0.0	3.0	4.0	0.0	0.2	0.0	0.2	1.6	0.2	5.8	6.6	8.2	8.6	0.0	1.8	0.2	6.8	4.6	3.0	0.0	114.8	1957
1958	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	2.8	0.0	0.0	0.4	0.8	1.0	1.6	0.0	0.0	2.2	0.2	4.4	9.6	0.0	0.0	0.0	0.0	0.0	26.0	1958
1959	3.6	0.0	0.0	0.0	0.0	0.0	0.0	2.8	3.0	10.0	8.8	10.0	4.0	5.8	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.4	2.4	2.4	9.6	6.2	10.0	5.6	10.0	0.2	0.0	95.2	1959
1960	4.6	0.0	0.0	0.0	1.8	7.2	2.2	2.6	9.2	7.6	8.0	10.0	6.4	5.4	1.0	1.8	0.8	0.4	0.2	0.2	1.8	3.2	0.8	1.2	5.2	10.0	1.6	0.0	0.0	0.0	93.2	1960
1961	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.4	0.2	0.0	0.8	0.4	0.0	0.0	0.0	0.0	1.2	7.4	10.0	4.6	0.0	29.4	1961
1962	4.8	0.0	1.4	9.8	9.8	8.0	4.2	0.6	6.0	0.0	0.8	0.4	0.4	0.2	2.4	0.0	0.4	0.0	0.0	0.0	0.8	1.0	2.4	0.6	8.2	8.6	0.0	0.0	0.0	0.0	70.8	1962
1963	5.4	7.8	0.0	4.4	1.0	0.0	0.4	0.0	1.6	0.2	0.2	4.0	0.0	0.4	2.0	0.0	0.2	0.0	0.2	7.6	4.6	1.2	0.2	5.2	5.4	5.2	4.8	10.0	4.6	0.0	76.6	1963
1964	3.8	0.0	0.0	0.0	0.0	4.6	6.0	0.0	6.8	0.2	0.2	0.0	0.2	0.8	0.4	0.0	0.0	0.4	0.4	1.2	0.2	0.6	0.0	1.6	3.8	9.2	8.8	2.6	0.0	0.0	51.8	1964
1965	3.6	0.0	0.0	3.6	1.6	1.2	1.0	5.6	0.8	1.2	9.2	6.4	4.6	7.0	2.0	5.4	0.0	1.0	0.0	0.2	2.0	0.0	0.0	1.2	9.4	10.0	7.4	9.4	0.0	0.0	93.8	1965
1966	4.0	3.4	7.6	5.4	2.2	4.6	8.8	1.6	1.0	4.8	0.6	2.0	1.6	0.0	0.4	0.8	1.6	0.0	0.0	0.0	4.8	1.6	0.2	0.0	0.2	4.6	10.0	2.6	0.0	0.0	74.4	1966
1967	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.6	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	3.8	1.8	9.8	8.6	0.0	34.6	1967
1968	7.6	0.0	0.0	0.0	0.0	0.0	0.0	5.8	10.0	8.2	0.2	0.6	2.0	0.0	0.2	2.4	0.2	0.0	1.6	6.0	0.2	0.4	0.0	2.2	2.6	8.6	8.2	0.8	9.0	4.6	81.4	1968
1969	6.2	0.8	3.0	8.6	4.8	7.2	0.8	1.6	1.4	9.6	6.8	2.0	0.2	0.2	0.0	0.0	0.0	1.6	0.8	0.0	3.2	9.6	0.4	0.0	0.0	5.8	10.0	3.2	0.0	0.0	87.8	1969
1970	5.6	8.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	5.0	10.0	6.4	0.8	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.6	0.0	0.6	0.8	7.8	4.2	0.0	0.0	0.0	53.6	1970
1971	4.4	0.0	0.0	0.0	0.0	0.0	0.0	1.4	1.4	1.8	9.8	10.0	3.0	5.0	0.2	1.4	0.2	0.0	0.2	0.0	4.4	4.2	4.4	7.8	7.2	4.6	0.0	0.0	0.0	0.0	71.4	1971
1972	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.4	1.4	1.6	0.2	1.4	6.8	1.6	9.8	1.4	0.6	8.0	1.2	7.4	2.6	0.0	48.4	1972
1973																																1973
1974	3.8	0.0	0.0	0.0	0.0	0.0	0.0	3.6	4.4	0.0	0.8	4.0	1.2	0.0	1.2	1.2	0.0	0.0	0.0	0.0	1.2	5.4	2.6	7.4	10.0	1.6	0.0	0.0	0.0	0.0	48.4	1974
1975	4.6	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.2	0.0	0.0	1.0	1.4	8.8	0.2	0.8	0.0	0.0	0.0	0.0	0.2	0.0	0.2	1.8	4.0	10.0	0.8	0.0	0.0	0.0	34.8	1975
1976	8.6	0.0	0.0	0.0	0.0	5.8	2.4	2.2	0.0	0.2	2.4	0.4	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0.4	7.2	7.2	5.4	10.0	4.6	0.0	0.0	0.0	0.0	0.0	57.2	1976
1977	5.0	0.0	0.0	0.0	4.6	0.0	0.0	6.6	9.0	0.6	0.0	0.8	0.2	0.0	0.0	0.4	0.2	0.0	0.0	0.0	0.6	9.0	1.2	0.4	7.0	2.4	9.4	3.8	0.0	0.0	61.2	1977
1978	6.6	0.6	0.0	0.0	0.0	2.4	0.0	0.0	0.6	4.4	0.0	0.0	0.0	3.0	10.0	5.2	0.2	0.2	0.0	0.0	1.8	3.2	0.6	5.4	4.4	7.8	9.6	7.6	0.0	0.0	73.6	1978
1979	7.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	1.0	0.0	0.2	1.4	0.2	0.0	1.2	8.4	2.4	6.2	1.2	5.4	10.0	8.6	9.0	10.0	1.6	0.0	0.0	76.4	1979
1980	5.6	0.0	0.0	0.0	0.0	0.0	4.0	7.6	6.2	5.0	8.4	5.2	5.2	0.8	9.6	9.6	9.6	10.0	7.2	10.0	10.0	8.4	0.2	0.0	3.0	5.2	1.0	5.4	4.6	0.0	141.8	1980

INSTITUTE FOR LAND AND WATER MANAGEMENT RESEARCH (I. C. W.)
P. O. BOX 35
W A G E N I N G E N
THE NETHERLANDS

SUDAN NUMBER OF NON-WORKABLE DAYS PER DECADE BECAUSE THE SOIL IS TOO WET

THE FIRST DECADE STARTS AT THE 1ST OF MARCH.

YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	SUM	YEAR
1941	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	9.0	10.0	9.8	10.0	10.0	5.0	8.4	2.6	10.0	10.0	9.6	10.0	3.0	4.0	5.6	1.8	9.4	2.4	0.0	0.0	0.0	132.2	1941
1942	4.4	4.0	0.0	0.0	0.0	0.0	0.0	7.2	9.8	10.0	9.8	10.0	10.0	10.0	10.0	10.0	10.0	9.8	10.0	8.4	5.2	1.2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	140.8	1942
1943	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	4.2	7.4	10.0	10.0	8.8	1.0	6.0	10.0	9.6	10.0	8.6	0.2	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	90.0	1943
1944	0.0	0.0	0.0	0.0	0.0	0.0	1.6	5.0	8.6	6.2	9.0	8.2	8.6	10.0	10.0	10.0	9.8	9.4	9.8	10.0	10.0	9.4	3.8	7.6	2.8	4.2	2.0	0.0	0.0	0.0	156.0	1944
1945	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	8.8	10.0	10.0	10.0	8.6	9.6	10.0	6.4	10.0	10.0	5.6	8.0	4.0	9.8	7.6	0.0	0.0	2.0	0.0	0.0	130.6	1945
1946	0.0	0.0	0.0	0.0	0.0	0.0	9.4	9.0	10.0	10.0	10.0	9.4	10.0	9.8	10.0	10.0	10.0	10.0	10.0	10.0	9.2	7.8	10.0	9.8	3.4	9.4	1.4	0.0	0.0	0.0	188.6	1946
1947	0.0	0.0	0.0	0.0	1.2	0.8	5.6	9.4	9.4	10.0	9.4	8.6	9.8	10.0	10.0	9.6	7.4	10.0	10.0	10.0	9.4	9.6	5.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	156.0	1947
1948	4.4	5.0	0.0	0.0	0.0	5.6	7.6	9.2	3.0	3.4	9.8	9.8	10.0	10.0	10.0	10.0	10.0	10.0	9.6	10.0	9.8	5.6	0.6	0.8	8.2	0.0	0.0	0.0	0.0	0.0	162.4	1948
1949	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	8.0	9.8	8.0	4.6	5.6	10.0	10.0	10.0	8.2	9.8	9.8	10.0	6.4	8.2	4.2	8.4	0.2	0.0	0.0	0.0	0.0	0.0	131.4	1949
1950	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	8.4	8.8	7.0	6.8	10.0	10.0	10.0	7.4	9.8	4.6	9.0	10.0	8.0	7.6	6.2	0.0	0.0	0.0	0.0	0.0	124.6	1950
1951	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	8.8	5.8	0.0	5.0	9.4	10.0	9.6	7.6	1.6	0.0	0.0	2.6	8.2	10.0	7.4	9.8	4.0	0.0	0.0	0.0	103.0	1951
1952	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.8	8.6	8.6	9.0	8.8	8.6	7.2	10.0	10.0	10.0	7.0	8.2	9.4	9.2	5.8	9.8	2.6	0.0	3.8	0.0	0.0	0.0	138.2	1952
1953	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	5.8	9.2	10.0	8.2	10.0	10.0	8.6	0.2	0.6	4.2	0.0	1.2	8.0	3.0	5.0	0.0	0.0	0.0	0.0	86.8	1953
1954	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	1.2	8.2	8.8	9.0	10.0	8.8	10.0	9.4	8.4	8.6	10.0	10.0	7.6	9.8	7.2	4.8	8.6	1.2	0.0	0.0	0.0	0.0	142.8	1954
1955	0.0	0.0	0.0	0.0	0.0	0.0	4.6	9.6	2.8	0.6	0.0	0.0	0.0	0.4	7.2	8.0	10.0	9.2	10.0	10.0	10.0	10.0	3.8	0.2	6.0	6.2	0.0	0.0	0.0	0.0	108.6	1955
1956	0.0	0.0	0.0	0.0	0.0	0.6	0.0	5.0	9.0	8.6	6.4	3.0	10.0	5.4	9.4	9.8	10.0	9.6	6.4	8.4	4.4	9.0	9.8	6.4	5.0	3.0	2.4	0.0	0.0	0.0	141.6	1956
1957	4.4	1.6	0.0	7.6	2.4	3.6	0.0	1.6	6.8	10.0	10.0	7.0	6.0	10.0	9.8	10.0	9.8	8.4	9.8	4.2	3.4	1.8	0.0	0.0	5.8	9.8	3.2	0.0	0.0	0.0	147.0	1957
1958	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.6	7.2	10.0	10.0	9.6	9.2	9.0	8.4	10.0	10.0	7.8	9.8	5.6	0.0	0.0	0.0	0.0	0.0	0.0	115.2	1958
1959	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	7.0	0.0	1.2	0.0	6.0	4.2	10.0	10.0	10.0	10.0	9.6	10.0	9.6	7.6	7.6	0.4	3.8	0.0	0.8	0.0	0.0	0.0	110.6	1959
1960	0.0	0.0	0.0	0.0	0.6	2.8	7.8	7.4	0.8	0.0	1.8	0.0	3.6	4.6	9.0	8.2	9.2	9.6	9.8	9.8	8.2	6.8	9.2	8.8	4.8	0.0	0.0	0.0	0.0	0.0	122.8	1960
1961	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	9.8	10.0	9.6	9.8	10.0	9.2	9.6	10.0	10.0	10.0	10.0	8.8	2.6	0.0	0.0	0.0	121.2	1961
1962	0.0	0.0	0.0	0.2	0.2	0.0	5.8	9.4	4.0	10.0	9.2	9.6	9.6	9.8	7.6	10.0	9.6	10.0	10.0	10.0	9.2	9.0	7.6	9.4	1.8	0.0	0.0	0.0	0.0	0.0	162.0	1962
1963	4.6	1.0	0.0	4.2	9.0	10.0	9.6	10.0	8.4	9.8	9.8	6.0	10.0	9.6	8.0	10.0	9.8	10.0	9.8	2.4	5.4	8.8	9.8	4.8	4.6	4.8	5.2	0.0	0.0	0.0	195.4	1963
1964	0.0	0.0	0.0	0.0	0.0	1.0	3.8	10.0	3.2	9.8	9.8	10.0	9.8	9.2	9.6	10.0	10.0	9.6	9.6	8.8	9.8	9.4	10.0	8.4	6.2	0.0	1.2	0.0	0.0	0.0	169.2	1964
1965	0.0	0.0	0.0	0.0	5.8	8.8	9.0	4.4	9.2	8.8	0.8	3.6	5.4	3.0	8.0	4.6	10.0	9.0	10.0	9.8	8.0	10.0	10.0	8.8	0.6	0.0	0.2	0.2	0.0	0.0	148.0	1965
1966	0.0	6.0	2.4	0.0	1.2	5.4	1.2	8.4	9.0	5.2	9.4	8.0	8.4	10.0	9.6	9.2	8.4	10.0	10.0	10.0	5.2	8.4	9.8	10.0	9.8	5.4	0.0	0.0	0.0	0.0	180.4	1966
1967	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	8.4	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	8.6	6.2	8.2	0.2	0.0	0.0	146.6	1967
1968	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	1.8	9.8	9.4	8.0	10.0	9.8	7.6	9.8	10.0	8.4	4.0	9.8	9.6	10.0	7.8	7.4	1.4	1.8	9.2	1.0	0.0	147.4	1968
1969	0.0	7.8	7.0	0.0	3.0	2.8	9.2	8.4	8.6	0.4	3.2	8.0	9.8	9.8	10.0	10.0	10.0	8.4	9.2	10.0	6.8	0.0	8.4	10.0	10.0	4.2	0.0	0.0	0.0	0.0	177.0	1969
1970	2.6	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.8	9.2	8.6	10.0	10.0	10.0	10.0	10.0	10.0	9.2	9.4	10.0	9.4	9.2	2.2	0.0	0.0	0.0	0.0	132.8	1970
1971	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	8.6	8.2	0.2	0.0	0.0	0.8	9.8	8.6	9.8	10.0	9.8	10.0	5.6	5.8	5.6	2.2	2.8	0.0	0.0	0.0	0.0	0.0	100.0	1971
1972	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.2	9.6	8.6	8.4	9.8	8.6	3.2	8.4	0.2	8.6	9.4	2.0	8.8	2.6	0.0	0.0	94.4	1972
1973																																1973
1974	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.6	10.0	9.2	6.0	8.8	10.0	8.8	8.8	10.0	10.0	10.0	10.0	8.8	4.6	7.4	2.6	0.0	0.0	0.0	0.0	0.0	0.0	130.6	1974
1975	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.6	9.8	10.0	10.0	9.0	8.6	1.2	9.8	9.2	10.0	10.0	10.0	10.0	9.8	10.0	9.8	8.2	6.0	0.0	0.0	0.0	0.0	0.0	159.0	1975
1976	0.0	0.0	0.0	0.0	0.0	3.6	7.6	7.8	10.0	9.8	7.6	9.6	10.0	10.0	9.8	9.8	10.0	10.0	10.0	9.6	2.8	2.8	4.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	145.4	1976
1977	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	3.0	10.0	9.2	9.8	10.0	10.0	9.6	9.8	10.0	10.0	10.0	9.4	1.0	8.8	9.6	3.0	7.6	0.6	0.0	0.0	0.0	142.0	1977
1978	0.0	0.0	0.0	0.0	0.0	4.0	10.0	10.0	9.4	5.6	10.0	10.0	10.0	7.0	0.0	4.8	9.8	9.8	10.0	10.0	8.2	6.8	9.4	4.6	5.6	2.2	0.4	0.0	0.0	0.0	157.6	1978
1979	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	10.0	10.0	9.0	10.0	9.8	8.6	9.8	10.0	8.8	1.6	7.6	3.8	8.8	4.6	0.0	0.0	1.0	0.0	0.0	0.0	0.0	114.8	1979
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	5.0	1.6	4.8	4.8	9.2	0.4	0.4	0.4	0.0	2.2	0.0	0.0	1.6	9.8	10.0	7.0	4.8	9.0	4.6	0.0	0.0	76.8	1980

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THE FIRST DECADE STARTS AT THE 1ST OF MARCH.

YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	SUM	YEAR
1941	5.2	8.4	10.0	10.0	10.0	10.0	10.0	10.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.4	10.0	94.6	1941
1942	1.4	0.0	4.6	10.0	10.0	10.0	10.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.4	10.0	10.0	10.0	10.0	10.0	10.0	113.8	1942
1943	7.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	0.6	5.2	10.0	10.0	10.0	10.0	10.0	154.0	1943
1944	6.2	10.0	10.0	10.0	10.0	10.0	5.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4	10.0	10.0	87.4	1944
1945	6.4	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.4	1.6	2.4	10.0	111.0	1945
1946	5.4	10.0	10.0	10.0	10.0	9.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	10.0	10.0	75.6	1946
1947	5.4	10.0	10.0	8.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.4	10.0	10.0	10.0	10.0	10.0	90.2	1947
1948	0.0	0.0	5.4	5.6	3.4	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.4	10.0	10.0	10.0	54.6	1948
1949	6.4	10.0	10.0	10.0	10.0	10.0	10.0	4.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.4	10.0	10.0	10.0	10.0	119.4	1949
1950	5.8	10.0	10.0	10.0	10.0	10.0	10.0	10.0	2.4	6.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	9.6	10.0	10.0	10.0	124.8	1950
1951	7.2	9.4	10.0	10.0	10.0	10.0	10.0	5.4	7.0	6.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	10.0	7.2	0.0	0.0	0.0	0.0	0.0	2.2	10.0	10.0	127.0	1951
1952	7.2	10.0	10.0	10.0	10.0	10.0	10.0	5.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4	0.2	2.4	10.0	10.0	100.6	1952
1953	2.4	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	2.4	7.8	0.0	0.0	0.0	1.4	10.0	10.0	10.0	135.0	1953
1954	7.4	10.0	10.0	10.0	10.0	10.0	10.0	7.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.0	10.0	10.0	10.0	114.2	1954
1955	7.0	10.0	10.0	10.0	6.4	3.6	0.0	0.0	0.0	0.0	0.0	9.4	6.6	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.2	10.0	10.0	95.2	1955
1956	2.4	10.0	10.0	10.0	10.0	6.4	1.4	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.4	10.0	10.0	82.2	1956
1957	0.6	0.2	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	10.0	2.4	0.0	0.0	5.4	7.0	10.0	38.2	1957
1958	7.4	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	10.0	10.0	10.0	10.0	10.0	158.8	1958
1959	5.4	10.0	10.0	10.0	10.0	10.0	10.0	4.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	0.0	9.8	10.0	94.2	1959
1960	5.4	10.0	10.0	10.0	7.6	0.0	0.0	0.0	0.0	2.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.4	10.0	10.0	10.0	84.0	1960
1961	6.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4	10.0	149.4	1961
1962	5.2	10.0	8.6	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	10.0	10.0	10.0	10.0	67.2	1962
1963	0.0	1.2	10.0	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4	10.0	28.0	1963
1964	6.2	10.0	10.0	10.0	10.0	4.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	7.4	10.0	10.0	79.0	1964
1965	6.4	10.0	10.0	6.4	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.4	10.0	10.0	58.2	1965
1966	6.0	0.6	0.0	4.6	6.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.4	10.0	10.0	45.2	1966
1967	7.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	10.0	118.8	1967
1968	2.4	10.0	10.0	10.0	10.0	10.0	10.0	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4	71.2	1968
1969	3.8	1.4	0.0	1.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	1.2	0.0	0.0	0.0	0.0	6.8	10.0	10.0	35.2	1969
1970	1.8	0.0	8.4	10.0	10.0	10.0	10.0	10.0	10.0	4.8	0.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.8	10.0	10.0	10.0	113.6	1970
1971	5.6	10.0	10.0	10.0	10.0	10.0	10.0	6.4	0.0	0.0	0.0	0.0	7.0	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4	10.0	10.0	10.0	10.0	128.6	1971
1972	7.4	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.4	10.0	157.2	1972
1973																																1973
1974	6.2	10.0	10.0	10.0	10.0	10.0	10.0	6.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.4	10.0	10.0	10.0	10.0	121.0	1974
1975	5.4	10.0	10.0	10.0	10.0	10.0	10.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.2	10.0	10.0	10.0	106.2	1975
1976	1.4	10.0	10.0	10.0	10.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4	10.0	10.0	10.0	10.0	10.0	97.4	1976
1977	5.0	10.0	10.0	10.0	5.4	10.0	10.0	2.8	1.0	6.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.2	10.0	10.0	96.8	1977
1978	3.4	7.4	10.0	10.0	10.0	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	10.0	10.0	68.8	1978
1979	2.4	10.0	10.0	10.0	10.0	10.0	10.0	10.0	6.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0	8.4	10.0	10.0	108.8	1979
1980	4.4	10.0	10.0	10.0	10.0	10.0	6.0	2.4	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4	10.0	81.4	1980

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* THE NETHERLANDS *

*** SUDAN *** NUMBER OF WORKABLE DAYS. OF JUNE ONLY THE FIRST 15 DAYS ARE INVOLVED

YEAR	APRIL	MAY	JUNE	APRIL + MAY	MAY + JUNE	APRIL + MAY + JUNE	YEAR
1941	0.0	6.6	0.2	6.6	6.8	6.8	1941
1942	0.0	2.6	0.2	2.6	2.8	2.8	1942
1943	0.0	0.0	6.6	0.0	6.6	6.6	1943
1944	0.0	10.8	2.8	10.8	13.6	13.6	1944
1945	0.0	0.0	6.8	0.0	6.8	6.8	1945
1946	0.6	1.2	0.0	1.8	1.2	1.8	1946
1947	20.6	4.6	0.0	25.2	4.6	25.2	1947
1948	13.6	11.8	5.2	25.4	17.0	30.6	1948
1949	0.0	7.4	1.4	7.4	8.8	8.8	1949
1950	0.0	8.2	2.8	8.2	11.0	11.0	1950
1951	0.0	7.6	1.8	7.6	9.4	7.4	1951
1952	0.0	14.2	0.6	14.2	14.8	14.8	1952
1953	0.0	0.0	4.6	0.0	4.6	4.6	1953
1954	0.0	11.0	1.4	11.0	12.4	12.4	1954
1955	11.0	14.0	14.4	25.0	28.4	39.4	1955
1956	4.0	11.8	2.4	15.8	14.2	18.2	1956
1957	17.2	20.6	0.0	37.8	20.6	37.8	1957
1958	0.0	0.0	0.0	0.0	0.0	0.0	1958
1959	0.0	7.8	13.8	7.8	21.6	21.6	1959
1960	9.0	16.0	10.6	25.0	26.6	35.6	1960
1961	0.0	0.0	0.0	0.0	0.0	0.0	1961
1962	27.6	9.8	0.4	37.4	10.2	37.8	1962
1963	5.6	2.0	0.0	7.6	2.0	7.6	1963
1964	5.6	11.8	0.4	17.4	12.2	17.8	1964
1965	6.4	7.4	7.4	13.8	14.8	21.2	1965
1966	11.6	11.6	4.6	23.2	16.2	27.8	1966
1967	0.0	0.0	0.0	0.0	0.0	0.0	1967
1968	0.0	17.8	6.2	17.8	24.0	24.0	1968
1969	19.6	5.4	12.4	25.0	17.8	37.4	1969
1970	0.0	0.0	12.0	0.0	12.0	12.0	1970
1971	0.0	2.8	8.6	2.8	11.4	11.4	1971
1972	0.0	0.0	0.0	0.0	0.0	0.0	1972
1973							1973
1974	0.0	8.0	0.6	8.0	8.6	8.6	1974
1975	0.0	1.0	0.0	1.0	1.0	1.0	1975
1976	6.0	4.4	2.6	10.4	7.0	13.0	1976
1977	4.6	15.6	0.6	20.2	16.2	20.8	1977
1978	2.4	1.4	3.6	3.8	5.0	7.4	1978
1979	0.0	2.0	0.0	2.0	2.0	2.0	1979
1980	0.0	17.8	10.6	17.8	28.4	28.4	1980

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*** SUDAN *** NUMBER OF WORKABLE DAYS.

YEAR	SEPT	OCT	NOV	SEPT + OCT	OCT + NOV	SEPT + oct + NOV	YEAR
1941	1.6	20.2	17.4	21.8	37.6	39.2	1941
1942	10.4	16.4	0.0	26.8	16.4	26.8	1942
1943	5.6	23.0	0.2	28.6	23.2	28.8	1943
1944	0.0	11.4	23.4	11.4	34.8	34.8	1944
1945	4.4	8.6	18.4	13.0	27.0	31.4	1945
1946	3.0	2.2	18.8	5.2	21.0	24.0	1946
1947	1.0	17.8	0.0	18.8	17.8	18.8	1947
1948	1.0	22.4	13.4	23.4	35.8	36.8	1948
1949	3.8	13.8	6.6	17.6	20.4	24.2	1949
1950	6.6	5.0	13.4	11.6	18.4	25.0	1950
1951	13.6	3.8	12.0	17.4	15.8	29.4	1951
1952	6.0	6.8	20.6	12.8	27.4	33.4	1952
1953	24.8	8.8	18.4	33.6	27.2	52.0	1953
1954	2.6	9.0	10.2	11.6	19.2	21.8	1954
1955	0.0	19.4	16.2	19.4	35.6	35.6	1955
1956	10.8	5.0	19.4	15.8	24.4	35.2	1956
1957	15.4	14.8	12.6	30.2	27.4	42.8	1957
1958	1.8	11.2	4.6	13.0	15.8	17.6	1958
1959	2.4	15.8	23.8	18.2	39.6	42.0	1959
1960	5.4	3.0	15.8	8.4	18.8	24.2	1960
1961	1.2	0.0	13.6	1.2	13.6	14.8	1961
1962	0.8	7.2	13.6	8.0	20.8	21.6	1962
1963	12.4	11.6	15.4	24.0	27.0	39.4	1963
1964	2.4	2.0	24.0	4.4	26.0	28.4	1964
1965	2.2	5.6	27.2	7.8	32.8	35.0	1965
1966	5.4	1.2	17.4	6.6	18.6	24.0	1966
1967	0.0	0.0	11.8	0.0	11.8	11.8	1967
1968	7.8	3.8	18.2	11.6	22.0	29.8	1968
1969	7.4	6.0	19.0	13.4	25.0	32.4	1969
1970	1.0	1.2	12.6	2.2	13.8	14.8	1970
1971	8.6	14.6	9.6	23.2	24.2	32.8	1971
1972	8.4	12.8	12.2	21.2	25.0	33.4	1972
1973							1973
1974	2.4	19.2	6.6	21.6	25.8	28.2	1974
1975	0.2	2.4	14.4	2.6	16.8	17.0	1975
1976	11.6	23.2	0.0	34.8	23.2	34.8	1976
1977	4.0	9.2	20.6	13.2	29.8	33.8	1977
1978	4.4	10.8	22.6	15.2	33.4	37.8	1978
1979	15.8	20.4	24.2	36.2	44.6	60.4	1979
1980	28.6	5.8	9.8	34.4	15.6	44.2	1980

during these two month's. In the combination October-November the workability is considerably better than in September-October.

The workability data in autumn are probably affected by the way the model was operating. Because it was a bare soil model the evaporation was sometimes reduced considerably. If a crop is growing and transpiring in summer the evaporation can be much higher than from bare soil. That can influence moisture conditions after harvest so that more workable days can be present than this investigation is computing.

Probability graphs of workable days are given in Fig. 5 and 6. From these it is clear that most problems will arise by lack of workability in spring. To avoid workability problems in autumn the seedbed preparation should preferably be round November first. Then at least 10 workable days are available. But this means that the same field operations have to be executed round May first. According to Fig. 5 and Table 5 the probability of sufficient workable days is low.

Because this poor workability is mostly caused by drought an irrigation will be helpfull, when the rain comes too late in spring. It should be studied how workability is influenced by such a measure for sometimes an irrigation can cause too wet conditions in subsequent periods.

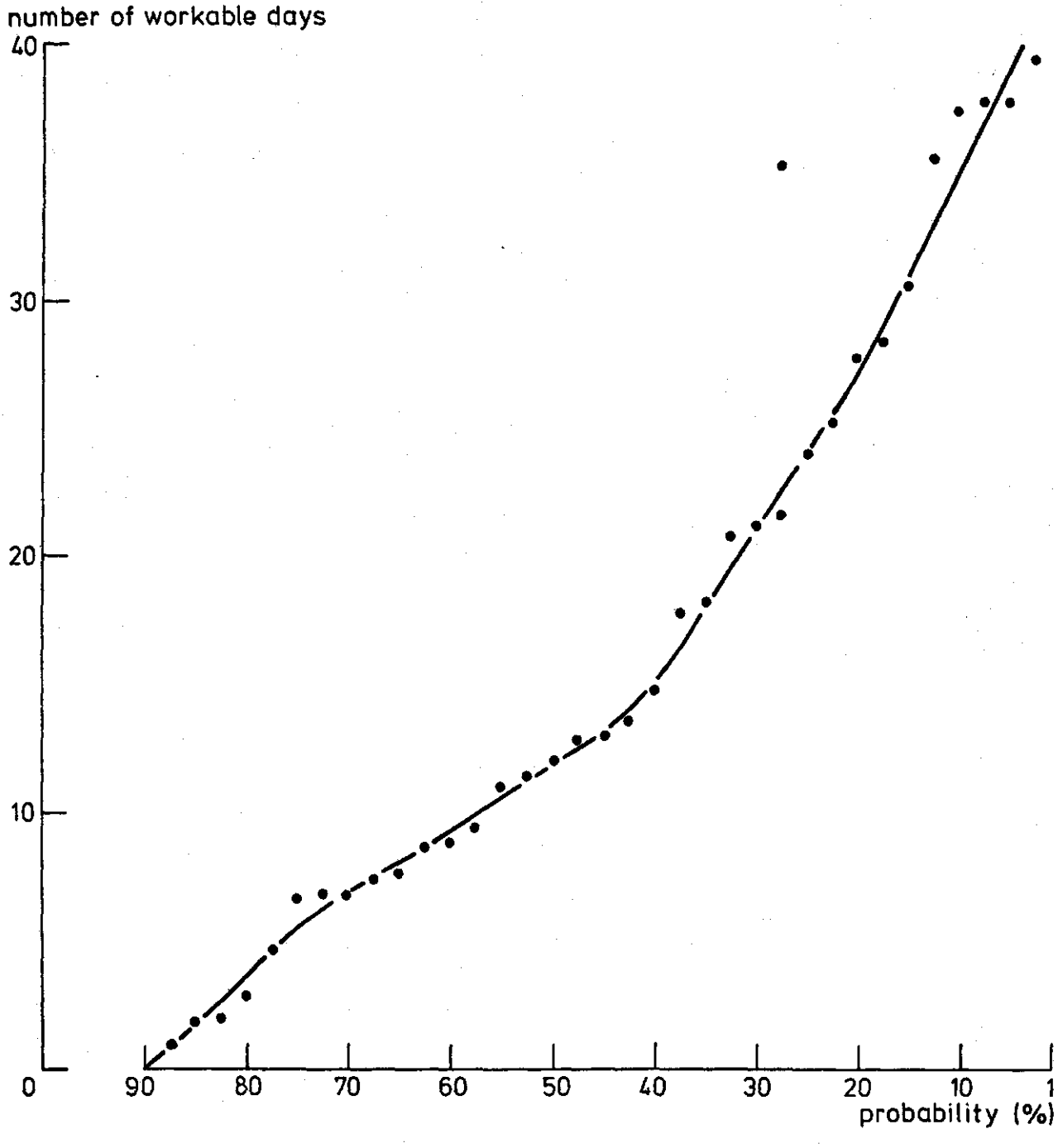

Fig. 5. Probability distribution of the number of workable days in spring between April 1 and June 15

SUMMARY

The number of workable days for seedbed preparation in the Pengko Plain in Southern Sudan has been investigated by model application. Over 39 years the moisture content of the top soil was simulated by the electronic analog model ELAN. Computed data were checked by workability observations in the field.

These seems to be a wide variation in workable days both in spring and autumn. Lack of workability in spring was caused by drought mostly and in autumn by water logging.

In spring 10% of the years had zero workable days; 20% less than 4. In autumn the period October-November is better than September--October.

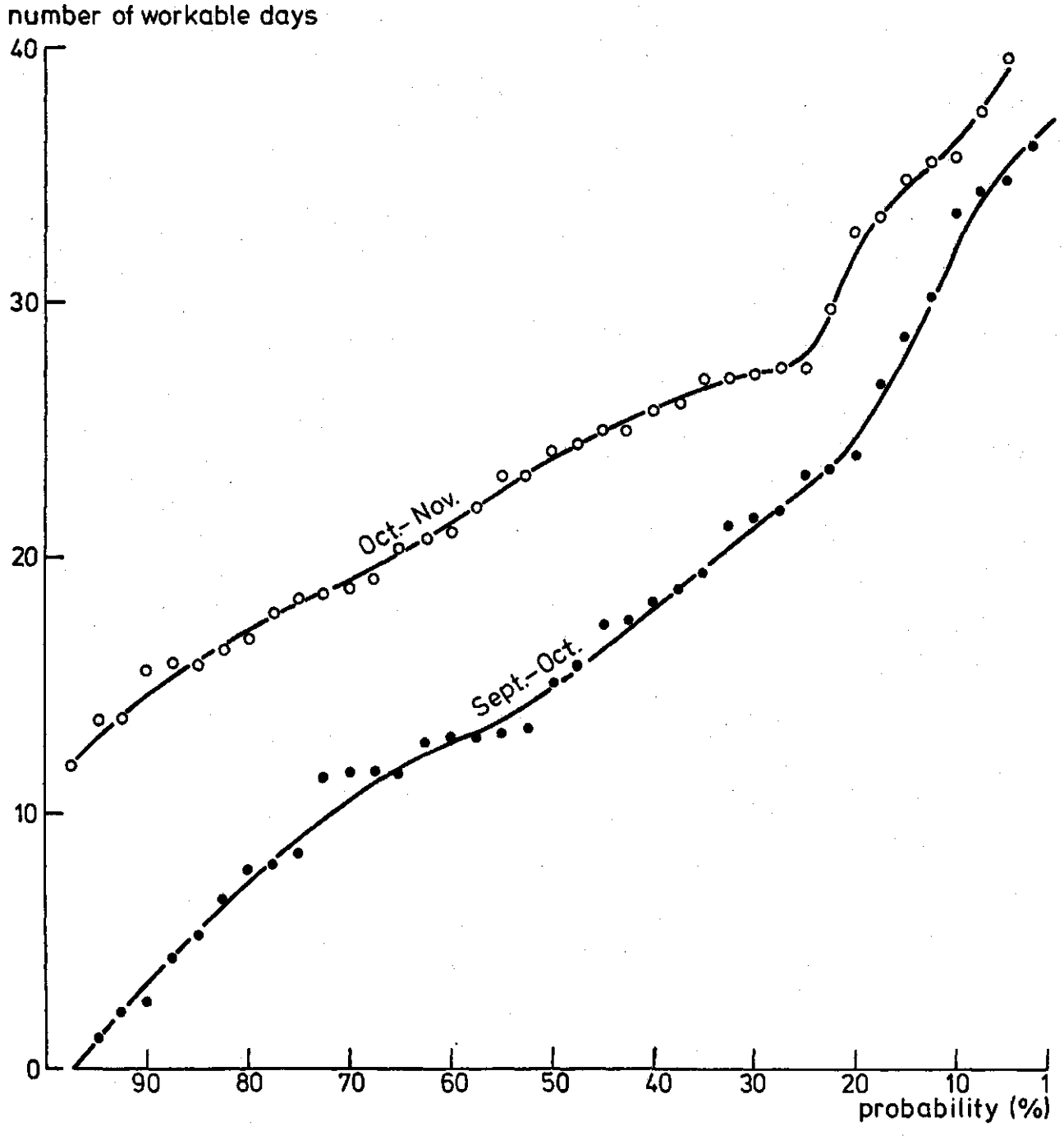

Fig. 6. Probability distribution of the number of workable days in autumn

LITERATURE

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