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Wageningen

WORKABILITY AND DRAINAGE

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Hun inhoud varieert sterk en kan zowel betrekking hebben op een eenvoudige weergave van cijferreeksen, als op een concluderende discussie van onderzoeksresultaten. In de meeste gevallen zullen de conclusies echter van voorlopige aard zijn omdat het onderzoek nog niet is afgesloten.
Bepaalde nota's komen niet voor verspreiding buiten het Instituut in aanmerking

CONTENTS

INTRODUCTION

Fertility of a soil, both physical and chemical, is certainly an important factor in determining suitability for agriculture. For modern agriculture the workability is already important and its significance is still growing. In the beginning of this century land prices of the fertile, poorly workable clay soils were twice those of the infertile, well workable sandy soils. Today one can buy two ha clay soil for the selling price of one ha sandy soil in the Netherlands.

Workability has been investigated less than fertility. Workability is affected by a large number of factors, e.g. drainage, structure, soil profile, preceding crop. But the most important factor governing workability is wheather. Its influence is so big that one cannot succesfully study the effect of other factors if not the influence of wheather is investigated first. This has seldom been done because of two reasons: firstly it was impossible to calculate moisture conditions of the topsoil from wheather data; secondly it is impractical research, for the wheather cannot be controlled.

Now that dynamic models are available of the unsaturated flow of moisture, the first reason has fallen away. It is now possible to calculate moisture condition, and thus workability, over a large number of years. And so it has become possible to investigate the effect of many factors on workability, with natural or standardized wheather conditions.

This paper discusses the effect of draindepth and drainage intensity on workability of a loamsoil in spring. For the investigation natural wheather conditions were used, and it seems now, that such research is certainly not totally impractical.

METHOD

Moisture tension in the top 5 cm was calculated during 23 years in the months January to the end of April, 5 times per day. Therefore an analog model of WIND (1972) was used and two numerical models of VAN KEULEN and VAN BEEK (1971) and of WIND and VAN DOORNE (1975).

These models can calculate the moisture condition at every depth and time by combination of the storage function (moisture characteristic) and the transport function of the unsaturated soil with the drainage function. The latter is expressed in depth and intensity.

The initial condition at January first was found by a rough calculation over the preceding eight months. The daily rainfall- and evaporation data of the meteorological station in De Bilt were used of each of the years between 1951 and 1973.

A description of the application of the models, the problems arising and their solution will be published by WIND, early in 1976 in Netherlands Journal of Agricultural Science.

The calculations could be checked by observations in all 23 years on the experimental farm Westmaas, fig. 1. The soil used is a loam soil, thought to be homogeneous, containing 25% clay.

The soil was considered as workable for planting when the top 5 cm had a moisture tension of -100 cm for grains and of -300 cm for potatoes and sugarbeets or when it was drier than these values.

The workable periods were calculated in 23 years for five drain-depths and three drainage intensities.

RESULTS

In figures 2 and 3 the effect of drainage intensity on total amount of workable days (criterion: $\psi < -300$ cm) before May first are shown for drain depths 80 and 150 cm below surface. A drainage intensity of 0,01 day^{-1} means that drainage discharge rate is 1 $cm.day^{-1}$ if the groundwater table midway between two drain tiles is 100 cm above the drains. A linear relation between discharge rate and hydraulic head was supposed to exist.

There seems to be but a small influence of drainage intensity on workability in spring. Fig. 3 shows considerable influence below an intensity of 0,003 day^{-1}. But that has no practical meaning. Thus poorly drained soils are not fit for arable agriculture because of inundations in winter. The design intensities used in the Netherland's drainage criterion are 0,023 and 0,007 day^{-1} for resp. 80 and 150 cm drain depth. According to WESSELING (1969) thus drained soils have a groundwater depth of 25 cm occurring once per year.

So in the appropriate range of intensities the choice of the drainage intensity does hardly affect workability in spring.

The effect of drain depth is shown in fig. 4 and 5. These give the amount of days in which the top 5 cm was drier than a moisture tension of 300 cm. In many years the effect appears to be considerable. A single year (1970) showed no workable days before May. Other years had few workable days combined with small effect of drain depth (1959, 1962, 1966). Many years were so dry (e.g. 1968) that even very shallow drainage gave a lot of workable days. In such years increase of workability has not much sense. In about half of the years there is considerable influence of drain depth in a relevant range of workability.

APPLICATION

A probability distribution of workable days in dependence of drain-depth is shown in fig. 6. This is of course only valid for this loam soil and the wheather of the used 23 years in the Netherlands and for the workability-limit of $\psi = -300$ cm.

The higher the workability, the smaller the required amounts of labour and equipment can be. Farmers will choose these factors so that in only few years (e.g. 2 out of 10) the normal spring works cannot be accomplished in due time. For low probabilities the workability at 150 cm drain depth is about twice that of 80 cm depth. Increasing drain depth from 150 to 200 cm looks not very helpful.

More probability distributions have been made from the model-output for every 5-day period in March and April. This will be used in an optimization model by the Institute of Farm Mechanics and Labour (IMAG). From thus obtained knowledge it will be possible to calculate drainage benefits for minimizing farm costs.

More workable days means also earlier workability in spring and that means earlier sowing and planting. Primarily the earlier workability of deeply drained soils is caused by their lower moisture content than that of shallow drained soils. This causes a difference of some days in a dry period. This difference is amplified strongly by the irregular rainfall pattern.

Fig. 7 gives the workable periods ($\psi < -300$ cm) during March and April for 4 drain depths in 23 years. The year 1960 has been omitted because the chosen initial condition at January first could influence the results considerably in that year.

In every year the soil was the earlier workable the deeper it was drained. In some years the difference was only small (1951), in other years very big (1955).

The relation between sowing time and yield depression was investigated by WIND (1960). With the aid of this paper and the workable periods given by fig. 7 VAN WIJK and FEDDES (1975) calculated the yield depressions, caused by lack of workability. They assumed that for sowing summer grains 5 days are required per farm and that sugarbeet and potatoes can be sowed (resp. planted) together in 5 days. Further they assumed that the farmer will use the first 5 available workable days.

The yield depressions thus calculated and averaged over 23 years are given in table 1.

Table 1. Yield depression caused by too late sowing, as a function of drain depth. The data are averaged over the period 1951-1973. After VAN WIJK and FEDDES

Drain depth cm	Summer grain %	Potatoes and sugarbeet %
40	36	12
80	18	7
100	12	6
150	8	4

The effect of drain depth is larger for summer grains than for potatoes and sugarbeet. This can be explained by the early period in spring in which the former crop is sown. During that time, February and March, evaporation is low and the amount of moisture in soil has big influence on the time which is required to obtain workability. Potatoes are planted, and sugarbeets are sown not before March 20, because of frost hazard. In that period evaporation is higher and soil moisture has less influence.

Table 1 gives the opportunity to calculate a benefit of drainage. Assuming that in 4 years 1 potato, 1 sugarbeet and 1 summer grain-crop occur, and that the value of the yield is 2000 $Hfl.ha^{-1}$ for summer grains and 4000 $Hfl.ha^{-1}$ for the other crops, the drainage benefit is 250 $Hfl.ha^{-1}.year^{-1}$ in the range between 40 and 80 cm depth. For the range 80-100 and 100-150 cm, the benefit is 50 and 60 $Hfl.ha.^{-1}.year^{-1}$ respectively.

These data are not sufficient, they have to be completed with the effect of drainage on farm costs, on workability in autumn, on water damage to crops and soil in winter. Moreover drain depth is a factor in drought damage which may occur in dry years.

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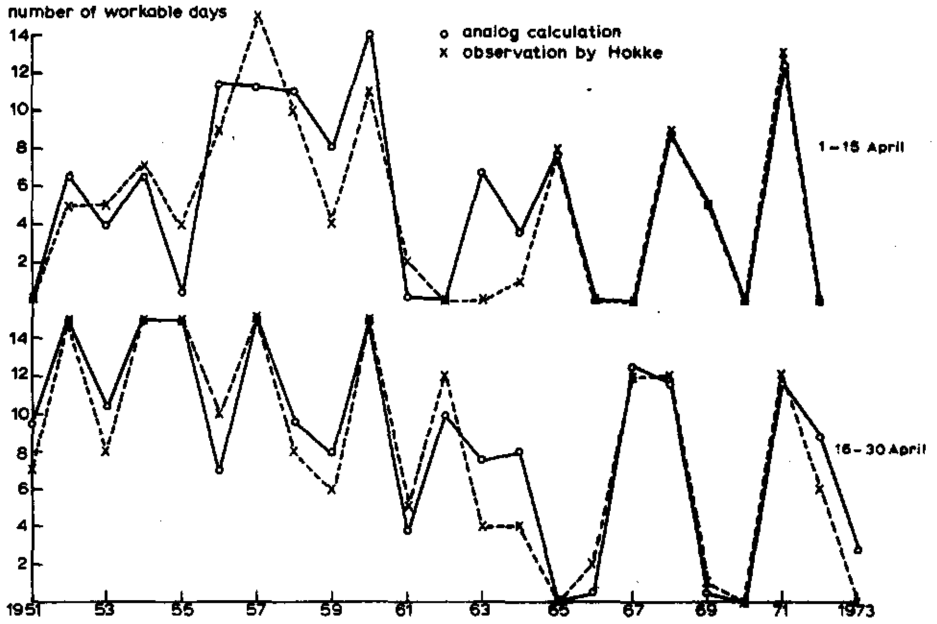

Fig. 1. Observed and calculated numbers of workable days in 23 years

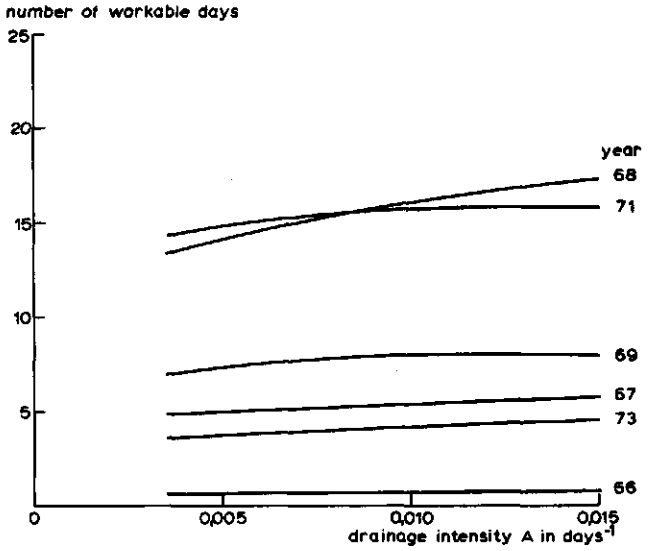

Fig. 2. Effect of drainage intensity on the total amount of workable days ($\psi < -300$ cm) in March and April for drain depth 80 cm below surface

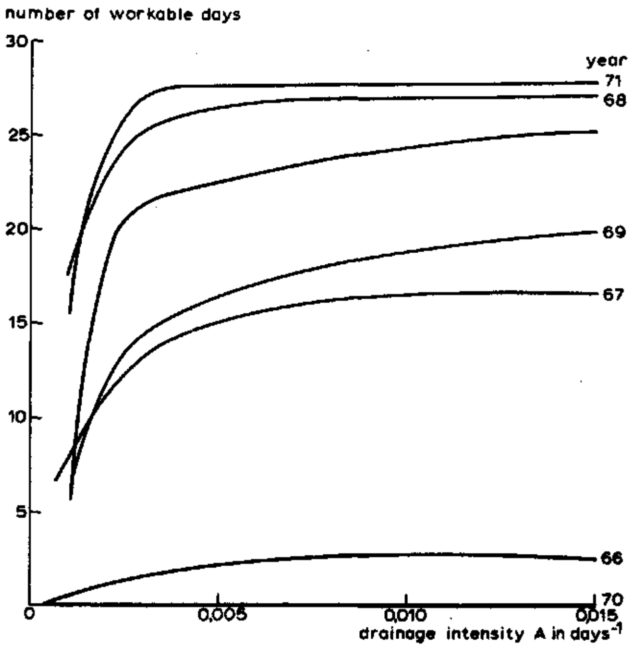

Fig. 3. As fig. 2 for drain depth 150 cm below surface

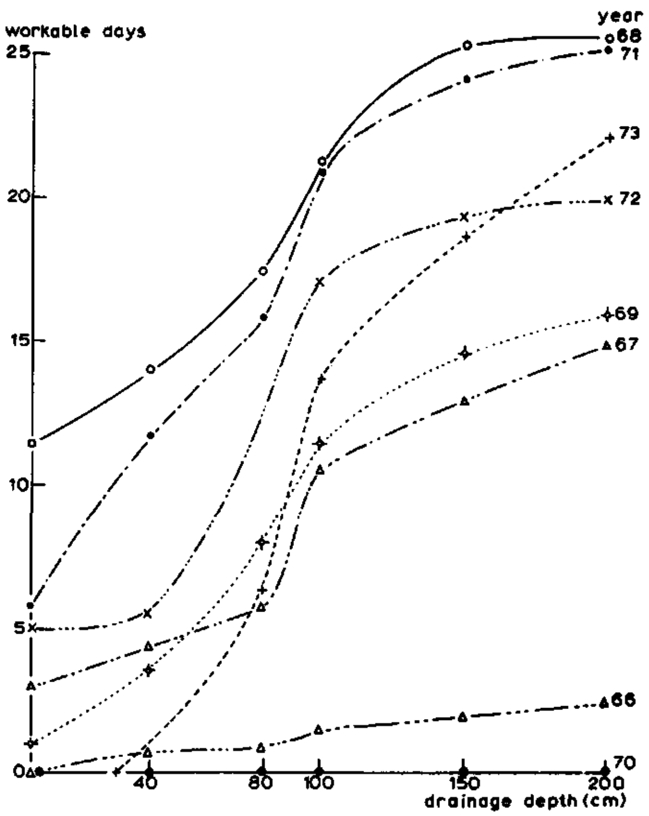

Fig. 4. Effect of drain depth on the total amount of workable days ($\psi < -300$ cm) in March and April for the last 8 years of calculation

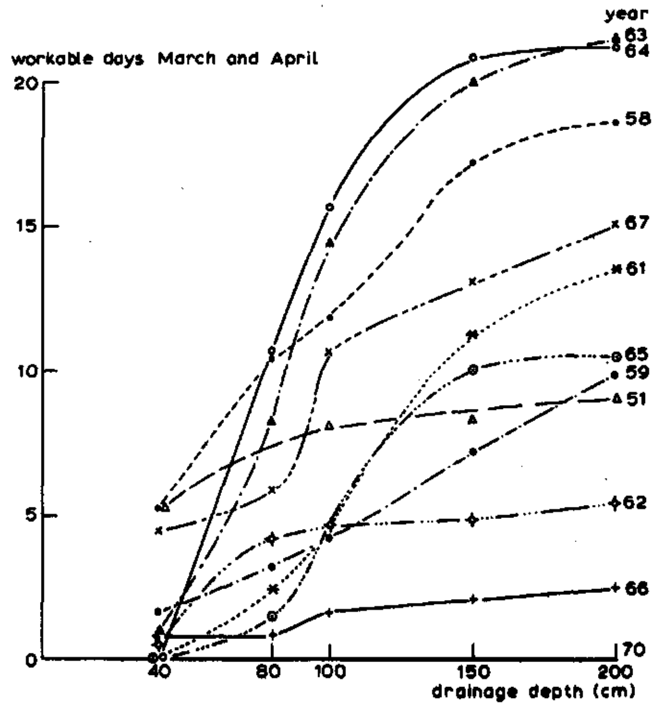

Fig. 5. As fig. 4, for the years with poor workability of shallow drained soil

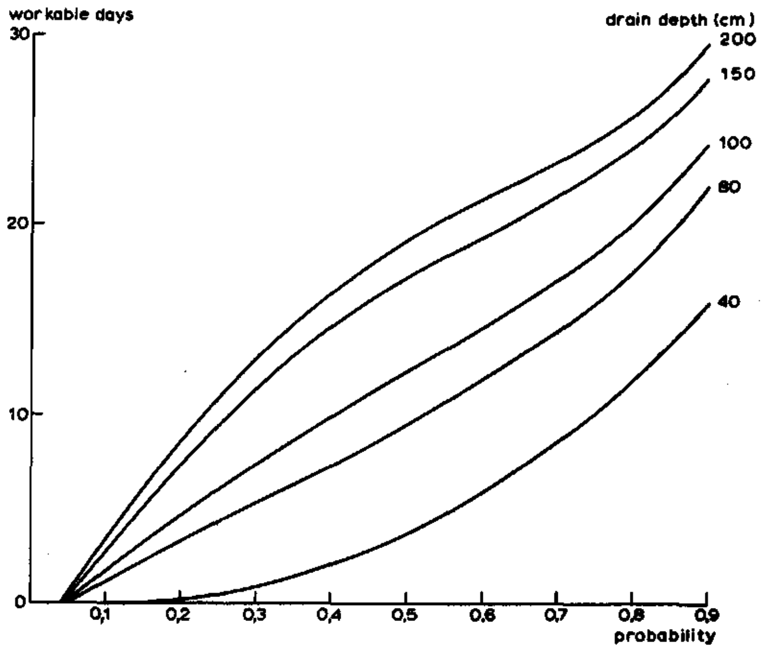

Fig. 6. **Probability distribution of total workability ($\psi < -300$ cm) in March and April**

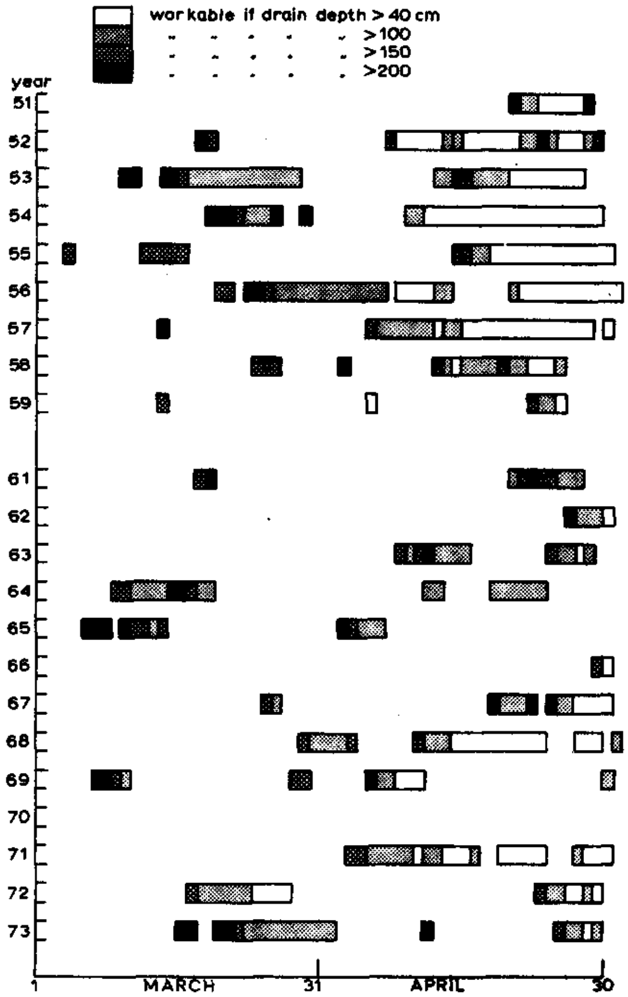

Fig. 7. Workable periods for 4 drain depths (ψ < - 300 cm)